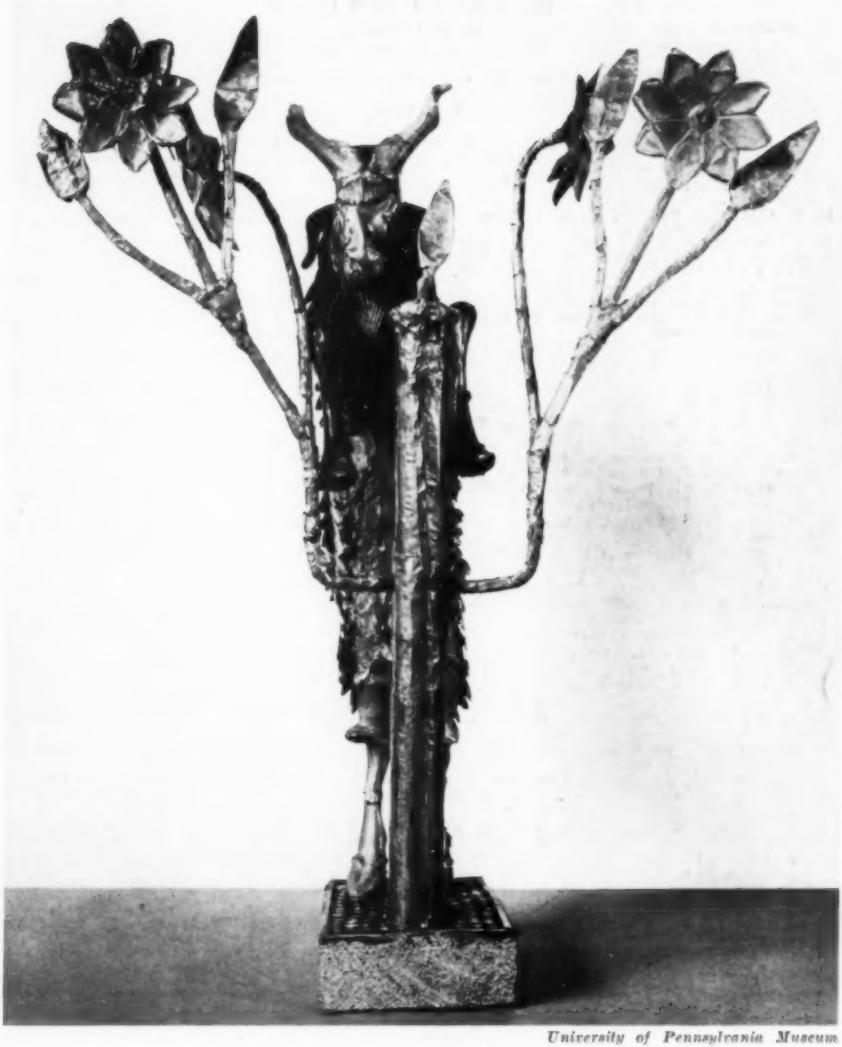
The Journal of HEREDITY



University of Pennsylvania Museum

PORTRAIT OF A RAM—3500 B. C.

(SEE PAGE 443)

VOLUME 26 NOVEMBER, 1935 NUMBER 11

The American Genetic Association

An incorporated organization devoted to promoting a knowledge of the laws of heredity and their application to the improvement of plants, animals, and human racial stocks

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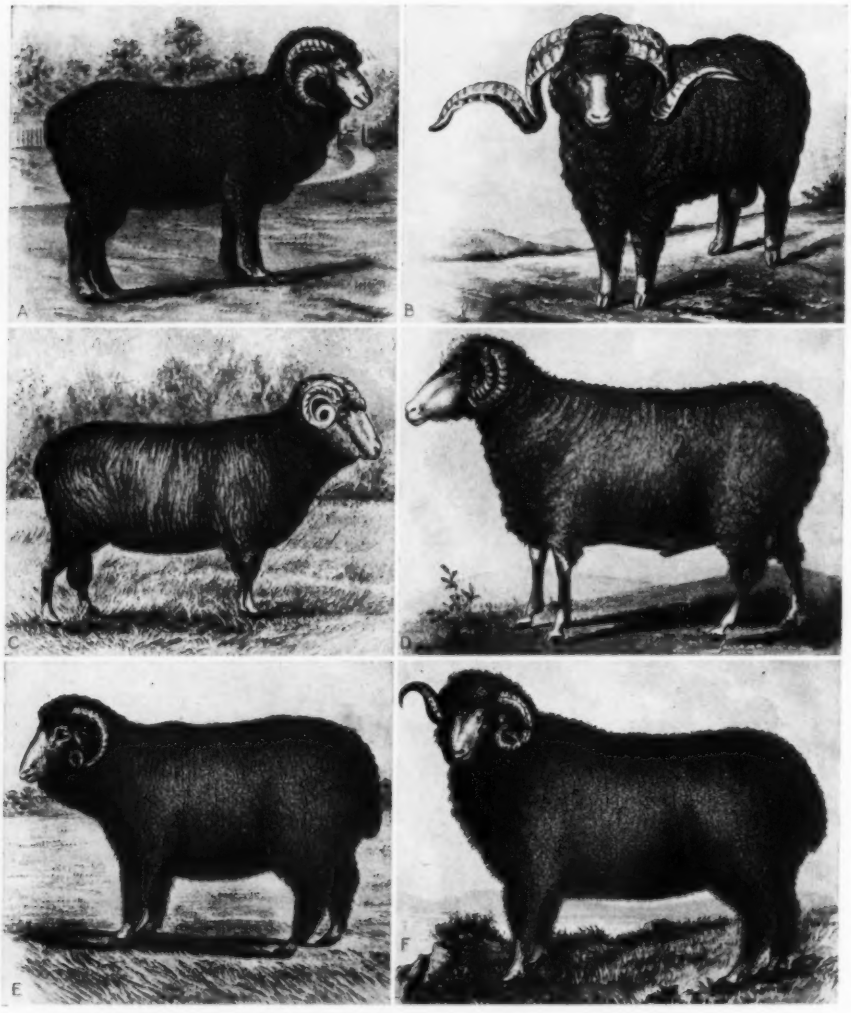


MERINO SHEEP OF THE EIGHTEENTH CENTURY

Frontispiece

The Merino sheep reached its highest development in Spain about 1700. By 1750 other European nations began to realize the importance of the fine-wool sheep to Spain, and the distribution of the breed began,—by gifts of the Spanish kings to their cousins in other countries, and by smuggling of sheep out of Spain. The illustrations reproduced here were redrawn from early sources and published in the special "Sheep Report" issued by the U. S. Department of Agriculture in 1892. *A* shows a Rambuillet ram of the year 1787. *B* shows the Spanish Merino ram "Don" presented to Arthur Young by George VI about 1790. *C* is a Spanish Merino ram imported into this country about 1800, and *D* is the Merino ram "Don Pedro" imported from France to the United States in 1801. *E* and *F* are Merinos owned by Robert R. Livingston, prominent in the early history of the United States and Minister to France from 1801 to 1805. *E* is a ram imported in 1802, and *F* is Livingston's ram "Clermont," 1810.

THE TREK OF THE GOLDEN FLEECE

ROBERT H. BURNS and E. L. MOODY
Wool Department, University of Wyoming

THE sheep is presumably one of man's oldest helpmates, for it was probably one of the first animals to be domesticated. It undoubtedly furnished the skins from which Adam and Eve fashioned coats after their expulsion from Paradise.[4*] Its remains have been found in the buried dwellings of the prehistoric lake-dwellers of Switzerland and it is shown on the earliest Egyptian monuments.[13] The biblical record tells us that Cain was a farmer and Abel a shepherd. Undoubtedly the first products of sheep which were used were their skins, which made coats, and their milk, which was used for food. The offering which Abel presented is spoken of in Genesis as the "fat thereof" and this was probably milk. From the same source we learn that the flesh of animals could not be eaten until after the Deluge. In Greek mythology the sheep plays a prominent part. In addition to the expedition of Jason to find the golden fleece, we need only recall the frequent references to sheep and shepherds in Homer.

The Domestic Sheep's Ancestors

We know very little concerning the remote ancestors of the sheep, but they undoubtedly are intimately related to the Urial and Mouflon types of wild sheep.[9c]

The Scotch Blackface sheep is one of the present breeds most closely related to the primitive type. Again there is considerable controversy regarding the origin of this breed. Pease gives a very interesting chart showing the domestic sheep as descended from intermediate forms of the Barwal or Tibetan sheep and the Mouflon or Sardinian and Corsican sheep.

Lydekker[13] gives a mass of zoological material concerning the sheep, and he states that there is good evidence to believe that the Mouflon forms the ancestral stock from which some of the European domesticated breeds have come.

Ewles[9d] made many crosses of primitive breeds of sheep and found that the Mouflon will cross with most of them, proving a close zoological relationship.

Shepherds Past and Present

Shepherds have, of necessity, always been nomadic folk who have lived solitary lives. From Jabal, who dwelt in a tent and tramped the rocky hills of ancient Palestine, to his modern prototype who plods over our own western hills, the shepherd has been a person of fearless deeds if not of heroic glamour. Much has been written concerning the romantic figure of the western cowboy, but his responsibilities were small indeed as compared with those of the humble sheep herder who is solely responsible for the welfare of two thousand helpless "woolies" through all extremes of weather and in the roughest kind of country. For each cowboy who has made the supreme sacrifice in stemming the roaring stampede, there have been many unknown shepherds who in raging blizzards have remained with their helpless charges to the end, and many cases are on record in which they have succeeded in saving their sheep only to perish themselves. This drama of the shepherd goes on even today, and very few winters pass without some testimony to the heroism of these unsung guardians of the flock.

*Numbered references are to Literature Cited, which will appear at the end of the article in the December issue of the *Journal*.

AN EGYPTIAN STATUETTE

Figure 1

Small stone statuette of ram from Egypt (here magnified about twice natural size). While the statuette is little more than a rough outline the Merino type of horns is definitely suggested. The ram was the principal deity of Elephantine and had an important place in the pantheon of that city. The ram of Mendes was the embodiment of Osiris in that town. Photograph courtesy of U. S. National Museum.

BRONZE RAM'S HEAD FROM EGYPT

Figure 2

This ram's head, made of thin plates of bronze soldered together, is hardly a Merino type, though resemblance to the horns of some of the Merino rams shown in later illustrations may be noted. The ram was sacred to Khnumu, one of the creator gods who formed men of clay. Photograph courtesy of U. S. National Museum.

Earliest Pastoral Industry

The skin of the sheep, in ancient times, was necessary both for clothing and for tents, and in a relatively short time felted wool and woven woolen material were also used for these purposes. The tent made of felted wool has served through many generations of shepherds, and its usefulness is attested even today in the "hogan" of the American Apache Indian as well as in the "yurts" of the wandering Kirghiz and Mongolian tribesmen.

Abraham, the patriarch of the Old Testament, thrived and prospered through the value of his great flocks and herds. The pastoral industry was thus one of the first agricultural pursuits to be firmly established as the fundamental industry of that time, and the herds and flocks served as a medium of exchange (Genesis, 13:2).

The Long Trek Begins

The cradle of civilization is supposed to have been located somewhere in Central Asia, and from this point the sheep has gradually been introduced to new localities until today it is found in practically all of the nooks and crannies of the globe. The Isrealites were great shepherds, and took their flocks to Egypt during their stay in that country. Their maritime neighbors, the Phoenicians, and later the related Carthaginians, were renowned as sailors and traders, and it was through their travels and dealings that the sheep was spread through all of the countries bordering upon the Mediterranean Sea.[5,15] The Romans and the Greeks both received their sheep from the East, and when Jason and his Argonauts of legendary fame[5,15] set out in search of the Golden Fleece they set sail towards the East, and in Colchis, on the southern shore of the Black Sea they are alleged to have gained possession of the Golden Fleece, after slaying the great dragon who guarded it.

Sheep Breeding

The Romans subsidized sheep breeding, and as a result the wool sheep developed to a point which had not been reached before, for they needed the best qualities of wool to make the regal

SUMERIAN RAM

Figure 3

Ram carved in steatite (?), of early Sumerian period, 3200-2700 B.C., from Wawka, Babylonia. The ancestors of the Merino sheep are supposed to have come from the East, and it is significant that this statuette of five thousand years ago definitely suggests the Merino type. When Jason set out to find the original Golden Fleece, he visited the shores of the Black Sea. Possibly the sheep found there were not unlike this form from Mesopotamia. Photograph courtesy of U. S. National Museum.

togas which were the distinctive raiment of the ruling class. At the time of Tiberius Caesar, Rome was furnished with the finest woolen cloth from Spain (cited after Livingston by Youatt[23]). Sheep, probably of the fine wool type, had been introduced into Spain by the Phoenicians hundreds of years before the Christian era.

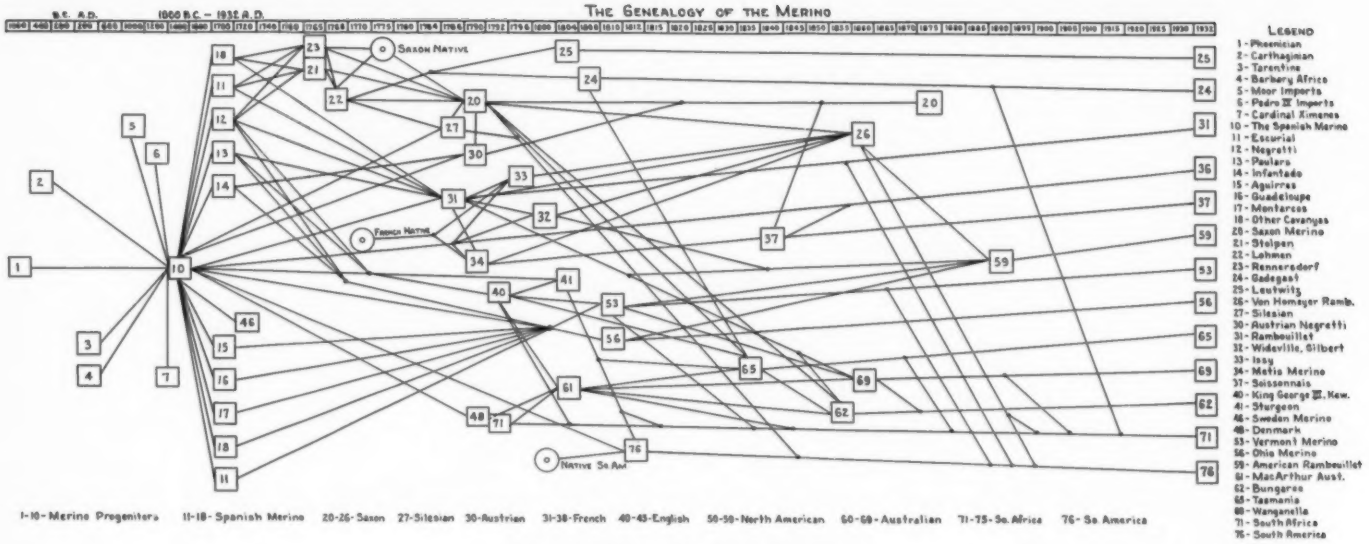
Origin

1000 B. C. to 1700 A. D.—2700 years

The origin of the Spanish Merino is enveloped in mystery and controversy, but there is little doubt that a number of different types of finer wooled sheep from Asia, Africa, Greece and Rome were brought into Spain in early times by the various conquerors, especially the Romans and the Moors, who were particularly interested in wool and textiles. The origin of the name Merino is controversial, and several derivations are given. Such widely different meanings have been suggested as: "thick, curly hair"[15] and "wandering," and "superintendent of the sheep walks," the latter found in early Spanish sheep husbandry. Still other meanings are given, and someone has stated that the ruling Berber family in northern Africa about the middle of the thirteenth century was named Merine.[5,15]

The development of Merino sheep husbandry in Spain is the saga of sheep breeding. Although sheep breeding and improvement had been known at an earlier date, it did not reach its fullest development until the appearance of the Merino in Spain. The business of raising sheep and manufacturing their wool into finely woven cloths was a most profitable one, and the entire Spanish nation profited handsomely from it. Elaborate precautions were taken to keep the industry exclusive to that country and the exportation of Merino sheep was prohibited.

Spain remained under the Roman rule from 6 A. D. to 456 A. D., and the sheep and wool industries had flourished and developed during these 450 years. Spain was then conquered by the Visigoths and held under their power for 250 years. At first the invaders plundered the country, but later they were content to settle down to an agricultural existence in the very favorable environment of Spain. When the Saracens or Moors conquered the country in 712 A. D., they found a flourishing agriculture. They, like their predecessors, were satisfied to settle down to a prosperous agricultural existence. The Moors were adept at manual arts and rapidly developed an extensive weaving industry, which became famous throughout the world. At the time of the discovery of America, Spain had become an independent kingdom under Ferdinand and Isabella. The Moors could not be tolerated in a Catholic kingdom in those times when intense religious persecution was rife, and they were persecuted and expelled from the country. When the Moors were driven out of Spain, the weaving industry suffered a distinct setback from which it never fully recovered. Even the tremendous wealth which



GENEALOGY OF THE MERINO

Figure 4

Summary-diagram showing the progenitors of the Merino breed from 1000 B.C. to the present time. Originating probably in the East, the Merino type of sheep may have been brought to the Spanish Peninsula by the Phoenicians and Carthagenians. Sheep were later brought from Africa from along the Barbary Coast and by the Moors. The various blood lines fused to form the Spanish Merino between 1400 and 1700 A.D. About 1750 the Merino began to spread over Europe. Soon after this it entered on the world-wide trek which has taken it to practically all the sheep raising countries of the globe. The blood of the Spanish Merino is to be found in nearly all of the important breeds of fine-wool sheep in existence today.

Spain discovered and controlled in the Americas could not make up for the loss, through the expulsion of the Moors,[5] of her agricultural and industrial wealth at home. A few of the Spanish noblemen foresaw the disastrous results which would come if the skilled Moorish artisans were persecuted and driven from the country, but they could not prevail in the face of the high Church dignitaries, who were very powerful and were determined to banish the Moorish race from Spanish soil.

Spanish Merino Families

About 1500

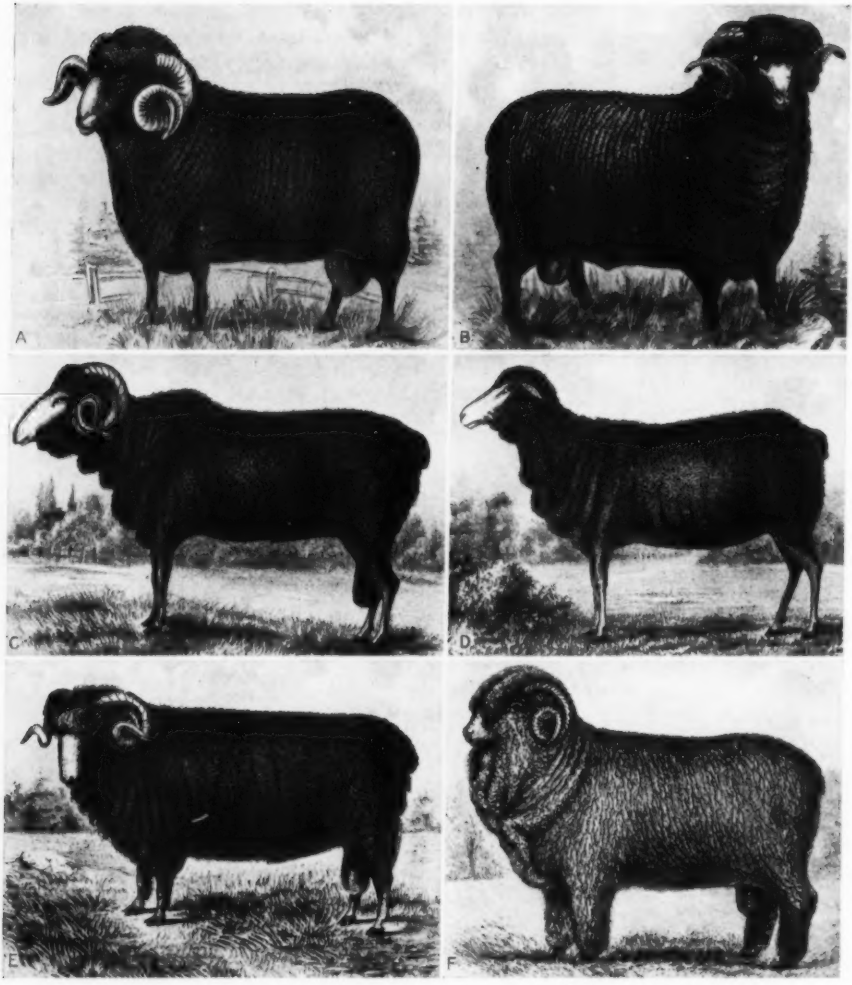
After the expulsion of the Moors, most of the Merino flocks passed under the control of the Sovereign. During the religious persecution which extended from 1248 until 1610 (Vincent[21]) little else was thought of in the fever of religious ferver, and when the Mohammedans were expelled from Spain the Catholic monarch and his dignitaries turned their attention to the Protestants. With such a state of unrest, and practically all of the industrial and agricultural people banished because of religious belief, the sheep and wool industries were sorely neglected. The fact that the Merino breed survived this neglect and kept most of its characteristic wool qualities shows that the breed was remarkably fixed in type, and also that there were undoubtedly a few Castilians who were aware of the great value of their sheep and took good care of them in spite of these troublous times. The exigencies of the State led to the gradual distribution of the royal flocks among the wealthy nobles and church dignitaries. The last of the royal flocks, numbering 40,000 head, was sold by Philip I to the Marquis of Iturbieta.[5] This would set the date of the founding of the Spanish cabanyas at around 1500.

Transhumantes and Estantes

1500—1700

The next period, roughly from 1500 to 1700, was the period when great flocks of travelling and stationary sheep made up the prevailing type of sheep husbandry in Spain. The Spaniards neglected the tilling of the soil and paid all of their attention to pastoral pursuits in which sheep predominated. The migratory sheep were known as the *transhumantes* and the flocks which remained in the same district for the entire year were known as the *estantes* or stationary sheep. The stationary sheep consisted partly of the larger sheep of the lower country, partly of mixed races, and partly of pure Merinos, which did not differ in any respect from the migratory sheep of that name except in the method of treatment.[12] The migratory sheep numbered about ten millions and made up about half of the sheep population of Spain. These migratory sheep were further subdivided into two kinds according to the kingdom in which they sought their summer feed; the *Leonese* and the *Sorians*. The sheep started north about the middle of April with their lambs born the previous November. Along the way they were sheared in large sheds, remarkably complete in their appointment for the orderly and proper preparation of the wool for market in the shortest possible time. The flocks reached the mountain pastures in about six weeks and remained there until the end of September, and then retraced their steps southward. Thus these hardy sheep learned to travel twice each year over a trail 400 miles long.[5,23] Is it any wonder that the Merino furnishes the best foundation blood for our range sheep today!

The annual trek of their ancestors is duplicated today in many sections of the West where the sheep travel from 100 to 300 miles between their winter and summer ranges. The Spanish sheep industry worked out a system of management for these migratory sheep which was and is a model of efficiency for the conduct of a flock. While on the trail, the sheep were divided into flocks containing about a thousand head, each of which was under the



MERINO RAMS OF THE EARLY NINETEENTH CENTURY

Figure 5

A is the Spanish Paular Merino ram "Fortune" (1811). *B* is one of the early Spanish Merino rams bred in this country by William Jarvis (1839). *C* and D are Electoral Escurial Merino ram and ewe from von Thaer's sheepfold at Moeglin in Prussia (1847). *E* is an Infantado Negretti Merino from the Hoschtitz sheepfold in Moravia (1847). *F* is a one-year-old French Merino ram, "Louis Philippe" (1849).

management of a head shepherd or *Mayoral,* who had a number of assistants akin to our "straw bosses" of today. The Mayoral must go ahead of the trailing flock and plan all movements of the flock so that it would move rapidly and quickly reach its destination. One of his most difficult jobs was to arrange for shearing, and that must have been a real task, for all details had to be attended to so that the entire flock of a thousand head would be sheared with but a single day's delay.[12] Low further states that 50,000 shepherds and 30,000 dogs were used in caring for the migratory flocks, and if there were ten million migratory sheep, this would allow a shepherd for each 200 head of sheep. The dogs were of the mastiff type and were used to protect the sheep from wolves rather than to help in driving them.

The entire system of the migratory sheep husbandry was regulated by a set of laws which were enforced by a special Tribunal called the *Mesta.* Laborde (cited by Brown[5]) states:

> The journey which the flocks made in their peregrinations is regulated by peculiar laws and immemorial customs. The sheep pass unmolested over the pastures belonging to the villages and commons which lie in their route and have the right to feed on them. They are not allowed to pass over cultivated lands, but the proprietors are obliged to leave a path 84 yards in breadth. In the grass land the flocks seldom travel more than 5½ miles a day, but when they are driven through the cultivated lands they sometimes travel 17 miles a day.

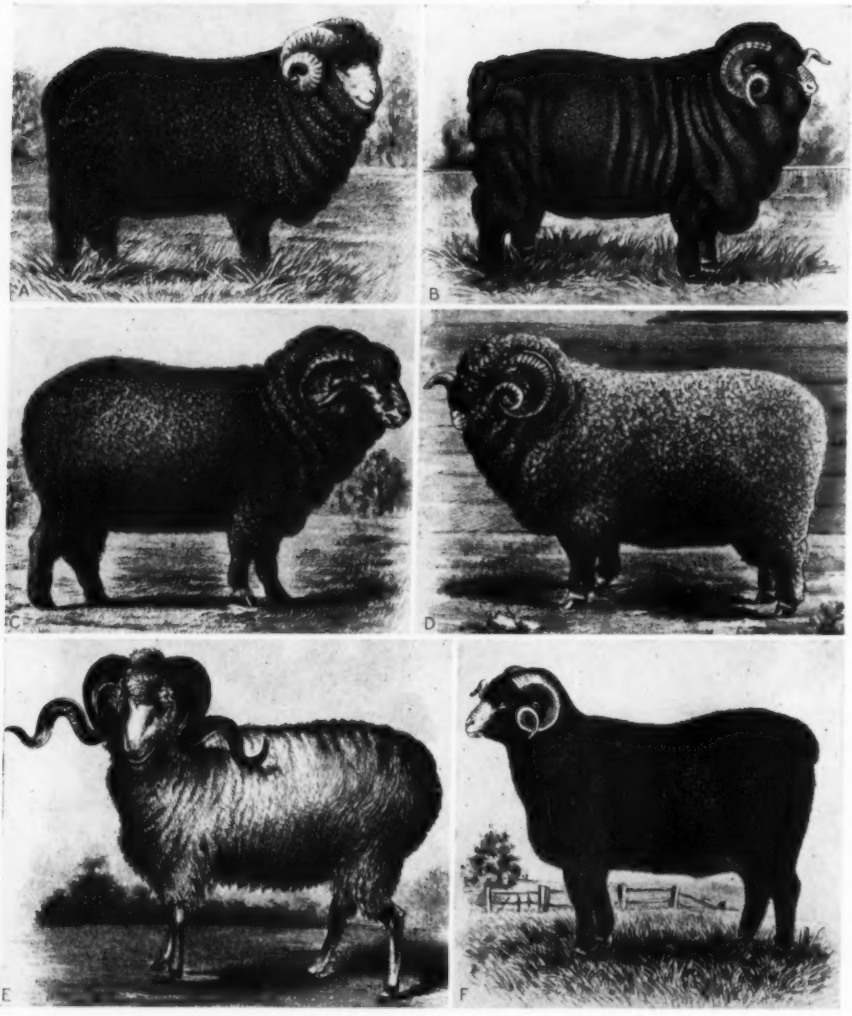
The *Mesta,* or council for the management of the migratory flocks, became one of the most powerful and one of the largest agricultural monopolies ever known in Europe and eventually usurped nearly all of the pasture land of Spain with great injury to the agriculturists. In the end the sheep owners themselves also were unable to escape the blighting effect of this huge monopoly.

In spite of its disastrous effects this tremendous interest in the sheep industry resulted in the development of a superior type of fine wool sheep, although there was considerable variation in the different cabanyas. The *Paular, Negretti* and *Escurial* cabanyas were withheld from exportation and retained their sheep to furnish wool for the royal manufactory at Guadalajara.[5] "Experienced breeder"[9] states that Sir Joseph Banks as well as Lasteyrie and Bourgoing are inclined to consider these three cabanyas or flocks to be the finest developed in Spain. The Spanish sheep were rather small, and Petrie (quoted by McIvor[15]) gave the weight of mature rams in fleece as 100 pounds, while the ewes in similar condition weighed 70 pounds. They were small in body proportions, and Haumann (cited in Spoettel and Taenzer[18]) gives measurements of rams of the Infantado, Negretti, and Guadeloupe cabanyas in which the height at the shoulder was around 2 feet, length of body 4½ feet, and length of staple from 2 to 2½ inches.

Prizes of Royal Favors and of Smugglers

1750—1800

By the middle of the eighteenth century the other countries of Europe began to notice that sheep raising in Spain was the most profitable of any of the agricultural pursuits. Moreover, it furnished the material for a highly skilled weaving industry which was the foundation of later industrial developments. Practically all of the royalty of Europe were more or less closely related and they lost no time in asking favors, either directly or indirectly, from their Spanish relatives; for they desired to obtain for their kingdoms some of the hoofed bearers of the golden fleece. Others did not take the trouble to ask for royal favors and smuggled sheep out through Portugal. The King of England followed such a procedure, and then later gained royal favor in Spain and was given a large number of excellent Spanish Merino sheep, whereupon he summarily dispatched all of the smuggled sheep, which had proven of inferior quality. It is more than probable that some sheep dealers in Portugal made a nice



AMERICAN AND SAXON MERINOS

Figure 6

The ram "Sweepstakes" was a fine example of the improved Spanish Merino as bred in Vermont, by W. S. and E. Hammond, in 1856. He weighed 140 pounds and sheared 27 pounds of wool in one year. "General Fremont" (*B*) was one of the heaviest shearing Merino rams of his day (1865). His first nine fleeces averaged 27 pounds, 1 ounce. Weight, 160 pounds. Bred by T. Stickney & Son, Shoreham, Vt. *C*, the Delaine Merino ram "Snowflake," No. 49, from the McDowell flock of Pennsylvania. He had wool of the remarkable length of five inches, with a beautiful crimp. A fine specimen of the Rambuillet ram of 1783 is shown at *D*. *E*. and *F* show Saxon Merinos when their breed was at its height—(1820-1868). The Saxon Merino represented the highest development of the fine-wool sheep as far as wool was concerned, but other important characteristics were sacrificed in developing a perfect fleece.

profit on those sheep! The first Merinos ever taken out of Spain were obtained by smuggling by a Mr. Alstroemer, of Sweden, who introduced them into his country in the face of great difficulties due to the severity of the climate and the prejudice of the sheepmen of that country.[15,23]

The Merino Goes to Germany

1765

In 1765, the Elector of Saxony, a cousin of the King of Spain, requested and obtained a present of three hundred sheep from the Royal Escurial flock. The Elector had in the past given a great deal of attention to the improvement of the native Saxon sheep and had watched with interest the success of the Spanish Merino. The King of Spain instructed the Mayoral of the Royal Escurial flock to select with the greatest care those sheep which were to be sent to Saxony, and thus strict selection at the beginning played an important part in the origin of the world-famous Saxon Merinos, which later ushered in the Era of the Golden Fleece in the years 1800 to 1850. Even the ministers of the gospel were enrolled to give their services in disseminating information on the care and feeding of these newly imported sheep. "In 1802 a proclamation was issued with all the pride and dignity of a great victory, that of the 16 million sheep on the German side of the Rhine, 4 million were noble, that is, of pure Merino blood."[15]

These selected Spanish Merinos under the meticulous care, shelter, and barn feeding of the Saxon shepherds developed the most marvelous fleeces the world had ever known. Unfortunately they were pampered too much and degenerated in size, constitution, and fertility, so that they became so delicate that they were most difficult to keep. Randall (cited by Brown[5]) states that he did not like the weakly Saxons, "but there was an atoning beauty about the wool of the Saxon which it was hard to resist. It flashed with such gem-like luster; it was so beautifully fine and even, and had such exquisite downiness of touch, that all other wools seemed base by the side of it." Spoettel and Taenzer[18] regard the extreme fineness of the Saxon wool with associated defects in shearing weight, excessive yolk, poor bodies and constitutions, as a result of intensive inbreeding and one-sided selection. The craze for superfine wool which brought fabulous prices led to the production of this type. The enthusiasts defeated their own purpose, for the product of their efforts was a breed which was delicate and showed serious defects in skeleton, fleece characters, body form, and constitution—sure signs of degeneration.

Saxon Merinos Today

The writer had the opportunity and pleasure of visiting the Gadegast flock in 1931. This flock has been maintained by the same family since 1807, and very little if any outside blood has been introduced. The sheep today are quite small but are fairly robust and carry fleeces of good fineness. This flock has held a distinguished place in Merino history and is still furnishing rams to many countries of the world.

Another famous flock nearby, the Steiger flock at Leutewitz, was also visited by the writer at that time. The sheep in this flock are of two types, the old, original wool type and a separately maintained flock of mutton Merinos of the dual purpose type. The wool type sheep are larger than those of the Gadegast flock and produce a fleece of good quality and bulk. This flock has been in the same family since 1805. Present economic conditions in Germany no longer favor the wool type Merino, and it is kept now, in the two flocks of Gadegast and Steiger, only as a family tradition and to furnish the finest of pedigree fine wool stock to customers in other countries, who still pay a premium for the fine-wool type of Merino as bred by these two families for generations. Mr. Steiger told the writer that he no longer kept many of the fine-wool type because economic

conditions forced him to carry the mutton Merino type in the majority of his flock, and he only kept a small nucleus of the old fine-wool type—"pretty robust rams at that" judging from those the writer saw—to furnish stud rams for past customers of the flock.

It is men like Mr. Steiger and the three generations preceding him, who devoted their lives to improving the grandest of wool sheep, who give one the highest type of inspiration. The fine old mansion and the substantial stone barns, excellently equipped and bounteously supplied with aromatic feeds, fairly breathe the traditions of this grand old family of master breeders. Here for generations, with steadfast purpose and skilful management, they have devoted their lives to the production of some of the finest wool sheep the world has known. The walls of the immense living room of the Steiger mansion are covered with prize ribbons won at the greatest of the Expositions of the past hundred years in all parts of the world. There are to be seen portraits of the famous Merino breeders of all nations and climes who have come to this shrine of the Golden Fleece! The names Steiger and Gadegast are indeed deeply graven on the scroll of fine-wool sheep breeders as two of the greatest names of Merino history, and they give us still a direct connection with the famous old Saxon Merino of the time of the Golden Fleece.

In the wool exhibit at the University of Wyoming are two exceptional samples of wool taken from the 1830 clip of a famous Saxon Merino flock. These samples set a standard of perfection (in fineness and length of fiber) which has not yet been equaled by any wool measured at the University (.0004 inch in fiber thickness). With a staple length of less than an inch they have the remarkable stretched length of over 2½ inches. They have a most distinctive sponginess and liveliness when handled and are excellent examples to demonstrate the distinctive characters which earned enduring fame for Saxon wools.

Otto Steiger, father of the present proprietor of Leutewitz, had a remarkable insight into future conditions and requirements to be met by Merino sheep. He states in a booklet written in 1890:

> I have thus been able to prove that it is not only possible, but even necessary in order to make sheep breeding really profitable, to select the pure Merino race for producing a high class of really fine wool on large framed animals with the disposition of getting easily fattened.[19]

Other German Merino Types

Silesian Merinos

We must speak briefly of other types of Merino developed in Germany. The Silesian type was only second in fineness to the Electoral of Saxony. Most of the breeding stock came from Austrian breeders to upper Silesia. All of the sheep bred in Silesia were, from the beginning, richer wooled and had a closer, shorter, and duller staple than the Saxon, and therefore corresponded more closely to the Negretti type.[18] The blood of the Paduan silk sheep was used in the flock of Count von Magnis, one of the principal Merino breeders of Silesia.

Prussian Merinos

Spanish Merinos were imported into Prussia[18] in 1748 and 1785 and were used on a native stock already considerably improved by Finke. These sheep were rather larger than the Saxon and were coarser wooled.

Von Homeyer Rambouillets

In the latter part of the nineteenth century the type most in demand was the combing wool type with larger and better proportioned mutton forms. A number of breeders in northern Germany started to breed the combing wool type and used in their improvement a great many French combing wool rams from the Government flock at Rambouillet and from other French breeders. Baron von Homeyer, at his immense estate at Ranzin in Pommerania, bred sheep of this type. His stock all came from the Government farm at Rambouillet. As will be noted

later, this same stock created a sensation at the World's Fair in Chicago in 1893, when they started a genuine boom for Rambouillet sheep in the United States.

Merino Precoce

During later years, mutton became more important in Germany, and due to economic conditions other factors such as early maturity and fertility became of vital importance in sheep production. The Mutton Merino or Merino Precoce was developed to fulfil these conditions. The German breeders drew from the French flocks which had already developed this type of sheep, as illustrated by the Dishley Merino, Soissonais, Chatillon, Berrichoun, and others.

The Mele Type

At the beginning of the twentieth century, Mr. Thilo, a breeder of the Negretti type of Silesian Merino, felt that the Merino blood was so immobile that a cross with a mutton breed with the right type of wool would be necessary in order to obtain satisfactory and quicker results in improving the mutton qualities of the Merino. Accordingly he made several trips to England and Scotland searching for a breed which would be suitable for his purpose. Eventually after many trips he saw the Border Leicester, a comparatively new breed, and was at once struck with their marked individuality, as well as their suitability in both body and fleece to fulfil the purpose he had in mind. The wisdom of his choice was more than vindicated by subsequent breeding tests. He called this new type of sheep the Mele, which name has a double significance, as it means crossbreed in French and also is composed of the first syllables of the two parental breeds, Merino and Leicester.

During the thirty years which have elapsed since the original crosses were made, the Mele has proved itself a remarkable type of mutton-wool sheep with a combination of desirable fleece characters along with exceptional mutton conformation, fertility, and early maturity. Mr. Thilo, whom the writer visited in 1931, has had the experience of a long battle to overcome the almost insurmountable prejudice of the Merino breeders, who were quite reluctant to give up their wool type and were certain that the Merino blood would be ruined by such crossing. However, the requirements of the market and changing economic conditions have borne out Mr. Thilo's contentions, and today there are few Mutton Merino flocks in Germany which have not used Mele rams. The writer was amazed at the size and conformation of the Mele rams at Neuenkirchen when he visited there in 1931. Here are rams which weigh over 200 pounds at sixteen months of age and have a nearly perfect mutton conformation which would do credit to any Southdown. Their well-filled quarters give one the impression that they are first cousins of the porcine family. Never has the writer seen such perfect mutton conformation combined with such size, and this observation has been confirmed by all who have seen them.

(Concluded in the December Number)

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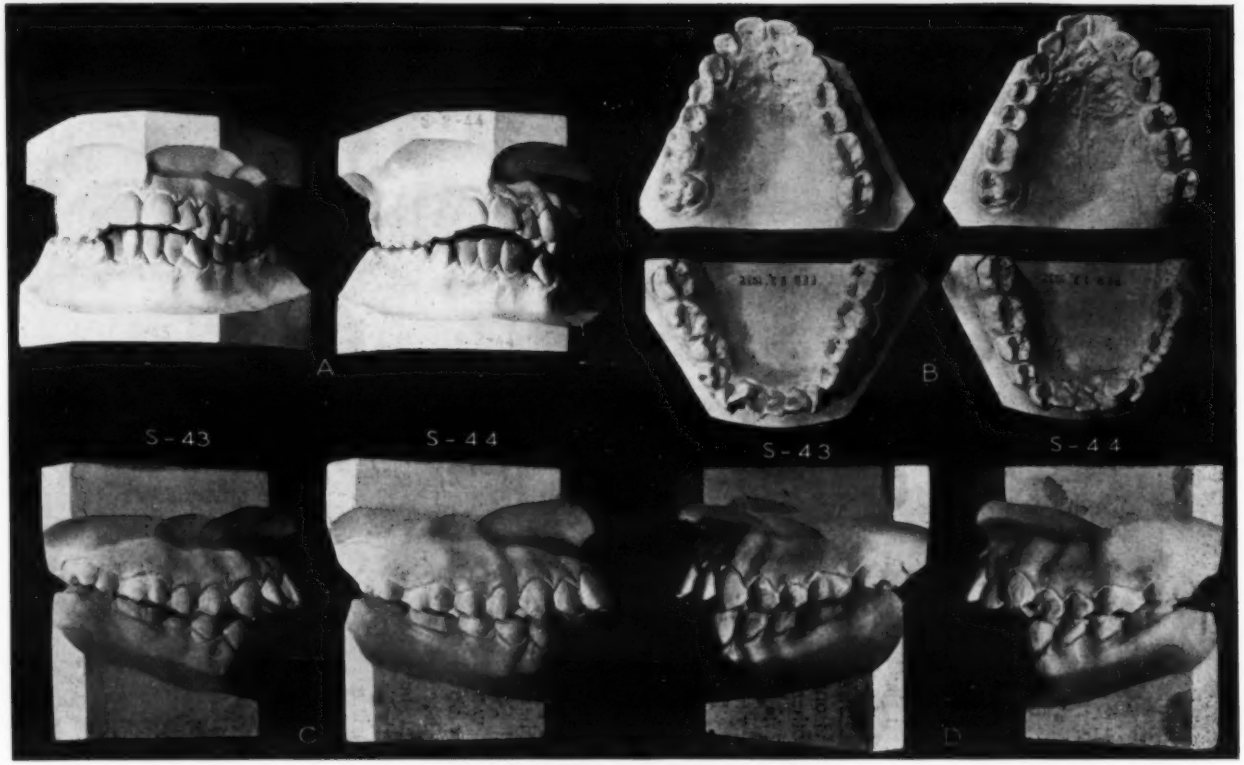
PORTRAIT OF A RAM—3500 B. C.

Description of Cover Illustration

The figure which is the subject of the cover illustration was found in one of the Royal Tombs at Ur, in Babylonia, dating before 3500 B. C. The ram is made of bitumen, with the petals of the flowers in shell and lapis lazuli. The "foliage" and the feet of the ram are of gold. Sheep from this region are believed to have been among the ancestors of the Merino. The ram here depicted is hardly a type of that breed, but the figure leaves little doubt that over fifty-five centuries ago the sheep was to be counted among man's livestock allies in Mesopotamia. Photograph courtesy of the University of Pennsylvania Museum.



SIMILARITIES IN TEETH OF TWINS

Figure 7

Four views of casts of teeth of identical twin sisters, aged 15. Note the astonishing similarity in the shape and size of both teeth and jaws. The only obvious differences are that in S43 the right lateral lower incisor is placed behind the other teeth, and in S44 it is the left lateral lower incisor that is so misplaced, suggesting mirror imaging so often found in identical twins. S44 had the lower left first molar extracted, and the second molar moved forward into its place. Compare the similarities here shown with the casts of the teeth of siblings used as control material shown in Figures 8 and 9.

AN EXAMPLE OF A SIMILAR TYPE OF MALOCCLUSION IN IDENTICAL TWINS*

MADGE THURLOW MACKLIN, *Medical School, London, Canada*
STEPHEN A. MOORE, D.D.S., *London, Canada*

ALTHOUGH it has been recognized for some time that certain tooth defects, such as absence of some or all of the teeth, are inherited characters, the condition of malocclusion has been generally considered as due to factors other than inherited ones. Incorrect diet, especially from the physical rather than from the chemical standpoint, was considered to be one of the causes of underdevelopment of the jaws. Food that was too soft, that did not give the jaws any work in chewing, was looked upon as partly responsible for the fact that the jaws failed to develop properly, and so was indirectly responsible for the crowded teeth later on in life. Thumb sucking, with the resultant pushing out of the upper teeth, and shoving back of the lower, was the bête noir of the mothers as well as the doctors who thought it would "spoil the shape of the child's mouth."

It is with the purpose of emphasizing the probable rôle of heredity as a causative factor in the production of malocclusion that the present case of that condition in identical twins is recorded. At a recent exhibition staged by dental surgeons other cases of malocclusion in identical twins were shown. Just how similar the defects were in the twins we do not know, inasmuch as the models were not seen by the authors.

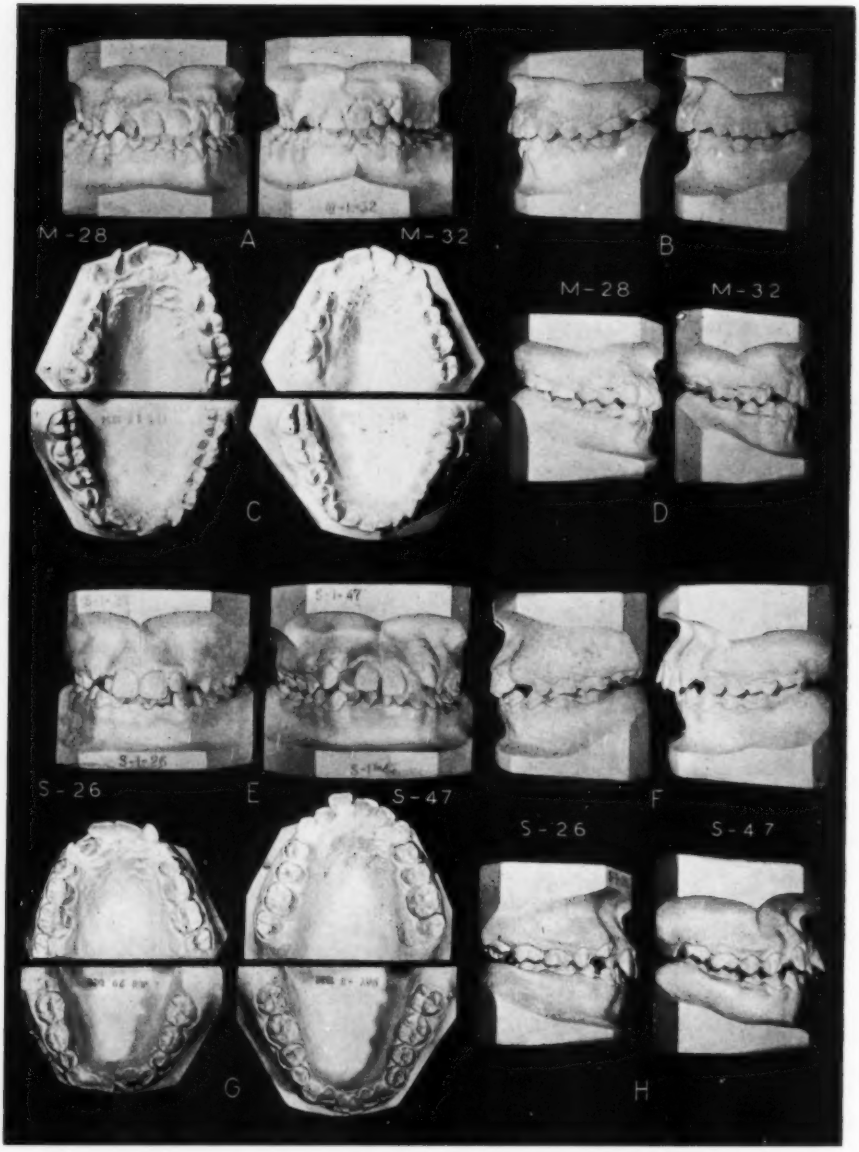
If identical twins resemble each other more closely than do fraternal twins or siblings in the matter of malocclusion, the inference that heredity plays a striking rôle in causing malocclusion is justified. Therefore the first point of proof in the case here presented must be that the twins are in fact identical. In support of that, the following items are offered. Both sisters are 62⅜ inches tall; K.S. weighed 110 lbs., B.S. 107¾ lbs. with their clothes on, although they informed us that in the summer with their bathing suits on, their weights were identical. Both have the same shade of golden-brown hair; both have the same shade of gray-blue eyes. The skin color in both is the same. Their color vision as tested by the Ishihara color tests was the same, (although this is not a very significant point since most females are the same in this respect). Their taste reactions to phenyl-thio-carbamide were the same, "slightly bitter." Both are right handed, both have double-jointed thumbs, both have an anti-clockwise hair whorl.

They resemble each other so closely that they have often changed escorts at their school dances, and gone home with the boy that brought the other twin, the boys being none the wiser. They like the same clothes, and dress in the same manner by preference. Their mental development is very closely identical; they say that they either tie for the same place in school work, or differ from the other twin by not more than one place. Palm and finger prints were sent to Prof. H. H. Newman of Chicago, who, with his son, very kindly analysed them for us. He stated that the twins were probably identical. The prints were not perfect, due to the fact that the palms were so hollow that it was impossible to get all the palm print on. Later, better prints were secured, following Prof. Newman's suggestions as to obtaining them, but the improved prints were not sent to him, as it was felt unnecessary to get further data on this point, the finger and palm prints being merely a subsidiary part of the study, in showing their identity.

The finger print formulae are as follows:

* Presented before the Royal Society of Canada, May 23, 1935, at Hamilton, Ontario.

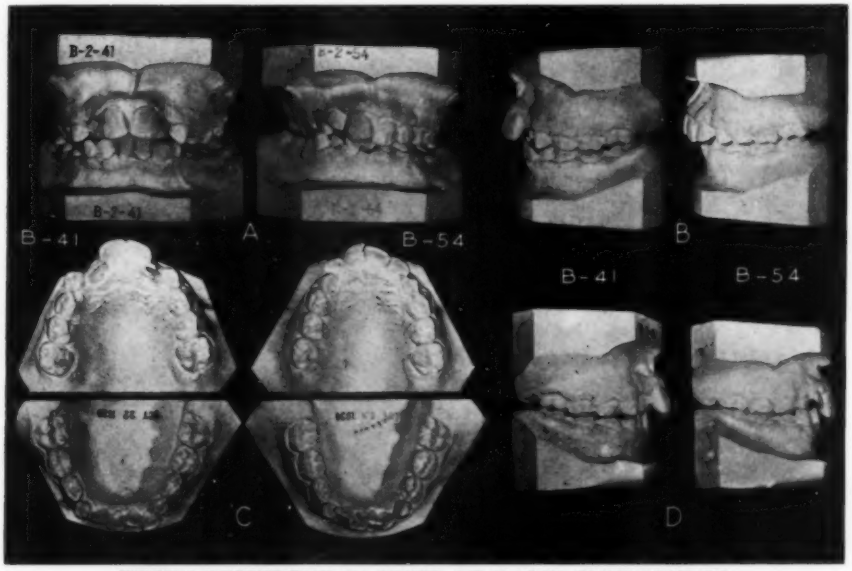
had the lower left first molar extracted, and the second molar moved forward into its place. Compare the similarities here shown with the casts of the teeth of siblings used as control material shown in Figures 8 and 9.



CLOSEST TOOTH RESEMBLANCE FOUND IN SISTERS

Figure 8

Four views of casts of teeth of two pairs of sisters whose ages differed by seven months at the time the casts were taken. The sisters, M28 and M32, resemble each other more closely than any of the other sibs examined in spite of the fact that one persistently sucked her thumb as a baby while the other never had this habit. The similarity between them is not nearly so close as that between the twins whose teeth are shown in Figure 7. In M28 (*A*), the lateral upper incisors point with their edges forward, while in M32 they face forward, and the canines are set much higher than in M28. Many other minor differences might be cited. The other pair of sisters (*E-H*) show greater differences in the shape and size of the teeth than do the twins or the siblings M28 and M32. Most conspicuous, however, is the variation of the position of the teeth with respect to one another, a point not brought out by the detailed measurements in Table I.



TEETH DIFFERENT IN SPITE OF HABIT SIMILARITIES

Figure 9

Four views of casts of teeth of a brother and sister whose ages differed by one month at the time the casts were taken. This pair differed more widely than either of the other control groups of siblings (Figure 8), both as to the measurements of the teeth and jaws and as to the positional relationship of the teeth to each other. Neither of these children sucked their thumbs or used pacifiers, but in spite of this both of them show the type of tooth displacement alleged to be due to these habits. Figures 8 and 9 are reduced by approximately one-half.

	Left	*Right*
K.S.	U Wr W Wu Wu	U U U Wu U
B.S.	U U U Wu Wu	U U U Wu U

and the palm print formulae are as follows:

Left

K. 9.9.5".H.-tt'-Lr-O-O-L-O. (total 27)
B. 9.9.5".H.-tt'-Lr-O-O-L-V. (total 27)

Right

K. 11.9.7.5'.-t- ?-O-O-L-O. (total 32)
B. 11.9.7.5'.-t-O-O-O-L-O. (total 32)

Their history relating to habits which might have influenced the mouth formation and dentition is as follows: They were premature, born at seven months; breast fed for three months; were mouth breathers; sucked their fingers; used no pacifiers; and had typhoid, measles and scarlet fever in childhood. Tonsils and adenoids had not been removed at time the casts were taken.

As will be seen from the casts of the teeth of the twins in Figure 7, *A, B, C,* and *D,* the upper jaws are practically identical, and the lower jaws are also, with two exceptions, namely (1) one twin, S44, had the left first molar extracted, and the second molar has moved forward into its place, and (2) one twin has the right, the other the left, lateral incisor in the lower jaw placed back of the other teeth. The resemblance between the two sets of teeth, especially in the upper jaw, both from the front, side and inside views is striking. The same is true of the lower jaw, if allowance is made for the mirror imaging effect just referred to.

In order to determine whether this close similarity was more than should be expected in siblings, three sets of children who had come as patients to one of us (S. A. M.) were selected for controls. These three sets were chosen for two reasons; the first was that they differed in age at the time the casts were

taken by not more than seven months in two cases and by only one month in the other case. The twins had been taken at exactly the same age. The second reason was that from a rather large series of cases in which more than one child in the family was affected, and which had been treated by S. A. M., these three groups of cases had been selected because they showed the strongest resemblance of one sibling to another of any set in the series, and so furnished the most rigid control for the testing of the degree of resemblance in the twins. Many others might have been selected in which the divergence between the siblings was so wide as to give no hint of family resemblance at all. To have selected these cases would have brought out the close similarity of the twins much more, but would not have been as good control material as are these cases which were chosen for their marked degree of family likeness.

These teeth are seen in Figures 8 and 9. M28 and M32 are two sisters who differed in age by seven months when the casts were taken. M28 never sucked her thumb and was not a mouth breather, while M32 sucked hers constantly for nearly two years despite many attempts to break her of the habit, was a mouth breather until her adenoids were removed. She also bit her nails. Both had their diets prepared according to the most approved pediatric practice of 15 years ago. Despite the thumb sucking, nail biting, and mouth breathing of one, and the absence of these habits in the other, the teeth of neither show any protrusion as in the case of the twins, and these two sisters resemble each other more closely than do any of the other sibling series, thus showing the effect of similar heredity with widely differing habit histories. It is of interest that the mother of these two sisters has the same type of malocclusion as have her daughters. Neither sister ever used a pacifier; the tonsils and adenoids were removed from M28 at the age of 5 yrs. 10 mos., and from M32 at 4 yrs. 6 mos. Both have had measles, chickenpox, mumps.

In the case of the other two sets of siblings, S26 and S47 had no history of thumb sucking and used no pacifiers, but S26 bit her lips, and S47 bit lips and finger nails. They had the usual childhood diseases. B41 sucked fingers and was a mouth breather, while B54 was a mouth breather, but had no record of thumb sucking. Neither used a pacifier.

Detailed Measurements

Although it was our impression that the twins resembled each other more closely than the siblings did, we desired some accurate measurement of this. Therefore a series of measurements was taken on the teeth in the casts with an instrument measuring to one hundredth of an inch, and on which with the aid of a lens figures could be read to one two-hundredth of an inch. The first measurements taken were the anterior-posterior diameter of the tooth at the points at which it touched the teeth in front and behind it. This need not necessarily mean the greatest diameter of the tooth, for if the tooth were set in the jaw obliquely, the measurement might be between points closer together than those at the ends of the greatest anterior-posterior diameter of the tooth. Nevertheless the distance between points of contact were so taken for the molars and the premolars. The greatest width of the canines and incisors was taken.

The second measurements taken were the shortest transverse lines across the jaw between corresponding right and left teeth, at the points on the teeth which projected furthest toward the midline. The third distance measured was the straight line from the back of the last tooth to the medial aspect of the central incisor on the same side. Finally, the angle at which the prolongation of a straight line touching the second and first molars on the right met a corresponding line from the left was measured. These were tabulated, and have been arranged in Table I. The average differences between the twins and between each set of siblings were calculated, and their probable error computed. In the tables the figures indicating hundredths of an inch are given as whole numbers, thus a tooth diameter which is

listed as 25 is really 25 hundredths, or a quarter of an inch.

From these tables it will be seen that the impression which one gained from the casts of closer resemblance between the twins is borne out by the measurements. The average difference between corresponding measurements in the twins was 0.0213 ± 0.002 inches, while the set of siblings most closely resembling each other, M28 and M32, differed by as much as 0.033 ± 0.003 inches. The set differing most differed by as much as 0.054 ± 0.005 inches, a difference twice as great as in the case of the twins. Nor do these measurements betray all the closeness of resemblance. The arrangement of teeth, their slant, their shape, their size, the evenness of emergence at the gum line, the number of cusps, the tilt of the lower teeth in to meet the upper, all are not included in the measurements, yet are revealed as points of similarity in the case of the twins, and as differing to a greater extent in the case of the siblings.

From the data here offered, we may conclude that although factors such as diet, thumb sucking, etc., may alter the shape of the jaw, and the manner in which the teeth are set in it, the evidence from this pair of twins who give strong indications of being identical, is in favor of the idea that a predominant rôle in causing not only malocclusions, but the type of malocclusions, is played by in-

TABLE I. Measurements of Teeth and Jaws of One Set of Twins and Three Pairs of Sibs.

	A - Twins S43-S44				Control Series											
					B.				C.				D.			
	Lower Jaw		Upper Jaw		Lower Jaw		Upper Jaw		Lower Jaw		Upper Jaw		Lower Jaw		Upper Jaw	
	S43	S44	S43	S44	M28	M32	M28	M32	S26	S47	S26	S47	B41	B54	B41	B54
R. C. I.	24	22.5	36	37	22	21	35	33	22.5	21	37	33	24.5	25	37.5	34
R. L. I.	27	26	27	29.5	25	23.5	28	25.5	24	24	27	26	26.5	25	31	33.5
R. C.	29.5	30.5	34.5	27	26.5	25	32	29	25	27	23	28	23.5	26	30	28
R. 1st. B.	30.5	27	27.5	28	26.5	26.5	26.5	25	25	27.5	25	27.5	33	30	33	28
R. 2nd. B.	30.5	31	29	28	26	26.5	24	24	28	28	24	27	35	37	36	34
R. 1st. M.	44	44	45	45	37	41	45	43	43	41	42	41	39	40.5	40	40
R. 2nd. M.	43.5	43	45	43	35	36	34.5	27	--	--	--	35	--	--	--	--
L. C. I.	23	23	35.5	35	23	22	35	32.5	22	20	37	33	23.5	23	36	35
L. L. I.	26	29	29	29.5	23	24	29.5	23	23	24	26	24.5	27	25	32	29
L. C.	29	29	33.5	33	27	25.5	31	29	25	25.5	--	29	24.5	25	30	26
L. 1st. B.	27.5	28	29	31	27	26.5	26	24	26	28	24	28	32	31	32	28.5
L. 2nd. B.	29	31	28.5	25	27	25.5	26	25	27	29	34	26	37	36	35.5	35
L. 1st. M.	44	missing	45	45	36	36	40	40.5	43	43	42	42	37	40	40.5	39
L. 2nd. M.	44	44.5	39.5	37	39	37	36	32	--	41	--	32	--	--	--	--
Trans. diam. between:																
2nd. M.	154	--	141.5	145	132	131	142	---	--	--	173	170	--	--	--	--
1st. M.	129	128*	129	130.5	124	124	117	119	126	124	128	141	135	121	127	107
2nd. B.	101	113	106	112.5	109	105	118	109	108	108	115	126	118	107	118	101
1st. B.	95	105	91.5	92	95.5	89	101	93.5	97	99	104	104	99	89	107	96
C.	82	87	80	87	75.5	73	101	94	81	79	--	104	78.5	76	95	82
L. I.	38	36	32	31.5	30	40	46	44	29	30	42	37	40	37.5	39	42
Distance from R. 2nd. M. to R. C. I.	198	199	227	227	178	186	200	190								
From L. 2nd.M. to L. C. I.	195	--*	225	225	187	180	204	194								
Distance from R. 1st. M. to R. C. I.									171	157	173	187	172	168	196	161
From L. 1st.M. to L. C. I.									151	162	170	182	165	158	189	186
Angle at which lines from back of jaw meet	51.5°	51.5°	49.5°	49.5°	56°	61°	38°	49°	55°	56°	37°	51°	56.5°	52°	33°	33°
Amount of projection of upper teeth beyond lower			37	41												
Average difference between comparable measurements	0.0213 ± 0.002				0.033 ± 0.003				0.045 ± 0.004				0.054 ± 0.005			

*The left second molar had grown forward into the position of the first molar, therefore the distance in S44 indicated between first molars is really between the right molar and the left second molar, which in this case is comparable to the measurements between first molars in S43. Owing to the lack of one tooth on that side the distance from the second molar to the central incisor was not comparable to the same measurement in S43. See casts of teeth in Figure 7.

EXPLANATION OF TABLE I.

R.C.I. Right central incisor
R.L.I. Right lateral incisor
R.C. Right canine
R. 1st B. Right first bicuspid
R. 2nd B. Right second bicuspid
R. 1st M. Right first molar
R. 2nd M. Right second molar
(Corresponding symbols for life side)

The measurements for teeth represent the anterior-posterior diameter of the tooth, and are given in one hundredths of an inch. Thus 45 means 0.45 inches. M28 and M32 were sisters whose casts were taken when the sisters differed in age by seven months, M28 being 14.4 and M32 13.9 years when the casts were taken. S26 and S47 are two sisters whose ages were 12.4 and 12.11 years respectively at the time the casts were taken, thus differing by seven months. B41 and B54 were brother and sister aged 9.4 and 9.3 years at the time casts were taken, thus differing by but one month in their ages.

herited factors. Strengthening this conception is the fact that siblings whose type of malocclusion is very similar still show a much wider divergence in their measurements than do the twins. Nor does the fact that the siblings were of different ages while the twins were the same age play a rôle in this greater difference among siblings. The teeth do not grow in size after they have come through the gum, and so age would make no difference in tooth size provided that the permanent teeth were through. Secondly, although age would make a difference in the size of the jaw, since bone would still be growing at the time the casts were made, the two children who differ most widely in measurements were those whose ages were nearest being identical, while the two children whose ages were removed by as much as seven months were most nearly the same in their measurements. Hence it is felt that the slight difference in age between the sibling group as compared with the identity in age of the twins when their casts were taken, cannot be looked upon as explanation of the greater difference in the sibling groups.

While it is advisable for children not to suck their thumbs, to have adenoids removed to prevent mouth breathing, and to be given food which requires them to exercise their jaws, too much should not be hoped for in the way of prevention of conditions of malocclusion by these methods. On the other hand, where the hereditary factor for malocclusion exists, the presence of these undesirable habits may well serve further to accentuate and make worse the hereditary condition, and hence should be eliminated.

In conclusion we wish to express our gratitude to the twins, Miss K. S. and Miss B. S., who have co-operated so heartily in making this study. We wish to thank very sincerely Prof. H. H. Newman, who, with the help of his son, was good enough to make the analyses of the palm and finger prints for us; also Prof. Charles C. Macklin, F. R. S. C., who introduced us at the Royal Society of Canada, and Mr. W. E. Downs for his photographic assistance.

✦

GROWTH OF THE CHILD

THIS book,* which has grown from the earlier studies carried out by the authors, is based upon systematic periodic examinations of the development of normal infants throughout the first year of life, and deals chiefly with the observations and genetic interpretations of behavior patterns. The results of this extensive survey are presented in six chapters which are subdivided into sixty sections—a feature greatly facilitating access to special topics.

The first two chapters describe the development and arrangement of the "normative project," present the basic genetic concepts, and outline the behavior categories, patterns and situations. In the third chapter the authors thus sum up their aims:

> [This chapter] which constitutes the core of the book summarizes the behavior characteristics displayed in twenty-five different situations, instituted at fifteen age levels from four through fifty-six weeks. The new-born infant was not included in our systematic observations. The period immediately after birth involves medical, nutritional and environmental complications, and so many highly variable factors that it requires special techniques for adequate study.

The genetic relations of the neonatal period to the fetal and postnatal life are discussed in Chapter Four, where the growth of posture and locomotion and adaptive behavior are particularly emphasized. The fifth chapter is on the rôle of maturation processes in the patterning of behavior, and among the topics presented one finds stimulating comments on the growth cycle and

(*Continued on page 462*)

*Gesell, Arnold, Helen Thompson and Catherine S. Amatruda, Infant Behavior (Its Genesis and Growth). Pp. VIII-343. New York and London: McGraw-Hill Book Co. 1934.

A TOMATO RELATIVE FROM PERU

J. W. Lesley*

A TOMATO COUSIN FROM PERU

Figure 10

Fruit cluster and flowering branches of *Lycopersicum peruvianum*, a species from Peru, whose relation to the tomato is just distant enough to offer interesting problems in cytology and genetics.

THE genus Lycopersicum Hill, distinguished from Solanum by connate anthers which dehisce longitudinally inwards, comprises ten species, according to Dunal in the *Prodromus* of De Candolle (1852). Five of them are so similar in appearance that they may be said to constitute the tomato group; these are: *L. pimpinellifolium, L. Humboldtii, L. pyriforme, L. cerasi-*

* Paper No. 330, University of California Citrus Experiment Station and Graduate School of Tropical Agriculture, Riverside, California.

CHROMOSOMES COMPARED

Figure 11

Chromosomes at diakinesis in pollen mother cells (× 3070). Left and center, two levels in one cell of a race of *Lycopersicum esculentum* Mill. with long A chromosomes. Right, *L. peruvianum* Mill, showing pair of large chromosomes not associated with the nucleolus.

POLLEN STIMULATION

Figure 12

Above, a seedless fruit of the variety Ideal Forcing, produced by self-pollination. Below, a seedless fruit of the same variety, produced by pollination with pollen of *L. peruvianum*. Thus far no viable seeds have been produced by this cross but the pollination stimulates fruit development.

forme, and *L. esculentum*. There is evidence that these five species or races intercross readily and are closely similar in their chromosome complement. *L. peruvianum* Mill. (*S. peruvianum* Jacq.), shown in Figure 10, hardly belongs in this group, but is sufficiently like a tomato to be of special interest to the plant breeder. It is indigenous to Peru, which has been supposed to be the center of origin of the cultivated tomatoes, and is known there as "tomate cimarrón."

In our cultures, *Lycopersicum peruvianum* differs from the tomatoes in having stipulate leaves; when mature, the berries are greenish with purple sectors It differs from *L. esculentum* in having canescent stems and leaves, more abundant trichomes, and smaller glandular hairs. Bracts commonly occur on the inflorescence. It should be noted, however, that purple sectors on the immature fruits, a leafy inflorescence, and canescent surface character occur in certain races of tomatoes. Moreover, Dunal, in the *Prodromus*, describes the berry of *L. peruvianum* as red. It closely resembles the tomatoes in flower color, to a less degree in leaf shape, and has the same number (twelve pairs) of chromosomes. The pair associated with the nucleolus has large satellites similar to those of certain cultivated tomatoes, but another pair is larger than the other tomato chromosomes (Figure 11).

When applied to the stigma of several tomato varieties, the pollen of *Lycopersicum peruvianum* readily caused fruit setting. The tomato fruits which resulted were normal in shape and color,

but the seeds were extremely small and failed to germinate in soil. No fruit set from the reciprocal cross. Pollen from certain unfruitful tomato plants, although nearly normal in appearance, when applied to stigmas of the same tomato varieties, failed to induce fruit setting. This seems to suggest that the pollen of *L. peruvianum* does not act merely as an irritant of the stigmatic surface of the tomato, but germinates and, by some metabolic activity of the pollen tubes, stimulates the ovary to develop. This easy method of producing seedless tomato fruits may prove useful to physiologists or even in commercial tomato production.

In the greenhouse in winter at Riverside, California, the tomato variety Ideal Forcing yielded 14 seedless fruits from emasculated flowers pollinated by *Lycopersicum peruvianum* which averaged 55 gm. (1.9 oz.), and 10 seedy fruits from selfing averaging 68 gm. (2.4 oz.) (Figure 12). The seedless fruits therefore were somewhat smaller, but in color, shape, and quality, they were very similar to the seedy fruits.

Altogether from 50 to 100 tomato flowers were pollinated with *Lycopersicum peruvianum* in the hope of inducing parthenogenetic formation of haploids, as suggested by Jörgensen* without success, but the attempt is worth making on a much larger scale, and under different climatic conditions.

✦

BOLSHIVIK GENETICS

THE author of this brief discussion of genetics in human affairs† shows a commendable tendency to make his treatment of a number of somewhat complex topics brief and concise. As a result there is bound to be a certain amount of dogmatism which cannot help but impress the reader. As long as brevity is confined to statements of fact no difficulties are created. In such situations dogmatism is excusable and perhaps wise.

It should be pointed out at once, however, that the author favors very definitely a socialistic society and that the chapters which deal with the application of biological principles to man are either consciously or subconsciously partisan. With this general point of view in mind the reader can evaluate more intelligently those portions of Mr. Graubard's volume which criticize other social, psychological or biological tenets.

In commenting on Madison Grant's *Conquest of a Nation* this reviewer some time ago stated his belief that frank admission of a partisan status helped any author to stand in a true light before his readers. Mr. Grant's attitude in this respect seems to the reviewer to be more admirable than is Mr. Graubard's.

The partisanship of the former is easier of detection and has no desire to disguise itself. Mr. Graubard's, however, must be picked from his text as a theme must be recognized in a musical composition.

Chapters on Laws of Heredity, Chromosomes, Heredity and Sex, and the Theory of the Gene, occupy roughly one-third of the text. These are reviews of the various important steps in the modern development of experimental genetics. The diagrams and figures seem to the reviewer to have been simplified to dangerously near a point where the average reader will fail to get much out of many of them. Otherwise these chapters are readable and sufficiently explicit to be helpful.

The chapter on "Evolution and its Present Status" begins to reflect the opinions of the author unadorned by a

*JÖRGENSEN, C. A., 1928. The experimental formation of heteroploid plants in the genus Solanum. *Jour. Genetics* 19:133-211.

†GRAUBARD, MARK. *Genetics and the Social Order.* Pp. 127, 75c. Tomorrow Publishers, New York, 1935.

sufficient amount of supporting evidence. He rules out the "struggle for existence" as described by Darwin in the following words:

> Such a concept as "the struggle for existence" even though it is used so frequently and so authoritatively by many people is a vague term more romantic and muddled than scientific and operational.

He makes a strange and somewhat out-of-date statement that mutated genes produce a new character "either as a dominant and recessive" or again that "lethals are of no concern to us." These sweeping generalizations will not be accepted in an unqualified form by a large number of biologists.

Perhaps the first clear example of the author's emotional attitude towards human biological problems is to be derived from the tone of his attack on "race" as a term. It is at this point that partisans on both sides of the controversy usually reveal themselves. Graubard's contention that "race" is inaccurately and illogically employed is sound. He might have said the same for such terms as "species", "type", "dominance" and a host of others which, however, serve useful purposes in the discussion of biological-sociological problems. His general conclusion seems to be that the term "stock" should be used instead of "race". Possibly "variety" or "strain" might also be worthy of consideration.

In the following chapter the first dulcet notes of the beauty of socialism and the correspondingly sour rendition of the "morals and ethics of the Stock Exchange" become clearly discernible in definite form. What Graubard describes as the "science of 'Human Nature'" might conceivably better be considered as his philosophical beliefs on the subject. The reviewer is able to find but little of "Science" in it.

Similar emphasis is to be found in the chapters on "Heredity in Man" and on the "Eugenic Program of Superiority and Sterilization". Various quotations will show clearly overstatement of principles.

Thus ". . . all human characters must have arisen by mutation."

"All such differences [i. e., in biological behavior] are determined by genes."

Eugenics is "an entirely new so-called *Science*." [sic. Galton, 1884]

"Eugenists act . . . as members of a society with a program rather than fellow investigators in a given field of research." [sic. Eugenics Research Association]

"There is no possible way of securing better biological offspring under such [i. e., modern methods of outbreeding] circumstances."

These and numerous other similar statements obviously indicate that all sides of controversial questions are not being equally considered.

One of the clearest examples of the shallow type of thought which he employs in criticism of eugenics is to be found in his reaction to sterilization. Here he strains at a gnat and swallows a camel. By objecting to sterilization until mental defects are proven to be genetic he assumes that mental defectives (even though their defect be nonhereditary) are good material to bring up children. He laments the possibility that power to sterilize might be placed in the hands of politicians and doctors, while advocating a type of social order in which the same powers, if granted, would be lodged in an even less controllable politico-social organization than the one at present operative in this country.

Near the end of his closing chapter on "Biology and Social Structure" occurs the following statement which sums up the personality of the book:

> . . . the Soviet Union which is today indeed the only scene of man in the making, a man of real culture and education, unpolluted by greed for wealth and for blood, by exploitation and oppression of others, by race and national hatred, by careerism and bigotry, etc. . . . etc.

The unfortunate thing about the book is that a younger biologist shows in his attitude that a socialistic state if established, will probably be as timid, blind and cowardly in facing the problems of human biology as has been our own capitalistic one.

C. C. Little

IS FECUNDITY IN SWINE INHERITED?

L. A. HENKE

Hawaii Agricultural Experiment Station

MANY swine raisers in selecting breeding stock prefer that the pig selected be one of a large litter, on the theory that pigs from large litters will in turn tend to produce large litters.

Complete records of a small herd of swine maintained at the University of Hawaii are available for the past fifteen years and they were examined for what answers they might give to the above question. The herd includes Berkshires and Tamworths.

During the period 1920-1935, 160 litters were born on which complete records as to the number of pigs produced in each litter as well as the number of pigs in the litters from which the sire and dam came are available. These litters were produced by 52 different sows and sired by 19 different boars. Condensed information about these 160 litters is shown in Table I.

The correlation coefficient between the number of pigs in the litters from which the sires and dams came and the number of pigs in the litters they produced are shown in Table II.

When by the method of partial correlation‡ the influences in turn of both sire and dam respectively are eliminated the correlation coefficients between the number of pigs in the litters the sires came from and the number of pigs in the litters which they sired are +0.065, —0.036 and +0.211 for the total, Tamworth and Berkshire litters respectively. In the same way the

TABLE I. Size of Litters

For All 160 Litters	*In litters from which sires came*	*In litters from which dams came*	*In litters produced*
Mean size of litters	8.86±0.10*	8.26±0.15	7.68±0.16
Maximum size of litters	12.	16.	16.
Minimum size of litters	6.	3.	1.
Standard deviation	1.95±0.07	2.75±0.10	3.06±0.12
For 89 Tamworth Litters			
Mean size of litters	9.67±0.12	8.45±0.22	7.73±0.24
Maximum size of litters	12.	16.	16.
Minimum size of litters	6.	3.	1.
Standard deviation	1.63±0.08	3.12±0.16	3.30±0.17
For 71 Berkshire Litters			
Mean size of litters	7.83±0.15	8.03±0.17	7.62±0.22
Maximum size of litters	12.	13.	14.
Minimum size of litters	6.	4.	1.
Standard deviation	1.84±0.10	2.17±0.12	2.73±0.15

TABLE II. Correlations of Litter Size

Correlation	160 *Total Litters*	89 *Tamworth Litters*	71 *Berkshire Litters*
Between number of pigs in litters sires came from and number of pigs in litters which they sired	+0.067±0.05	—0.048±0.07	+0.220±0.08
Between number of pigs in litters dams came from and number of pigs in litters they produced	+0.183±0.05	+0.166±0.07	+0.221±0.08
Between number of pigs in litters of sire and dam which when mated produced a given litter†	+0.017±0.05	—0.077±0.07	+0.068±0.08

*Probable error.

†Calculated only to provide means of determining partial correlation shown later.

‡FISHER, R. A. Statistical Methods for Research Workers (1925) pp. 150-156.

correlation coefficients between the number of pigs in the litters the dams came from and the number of pigs in the litters which they produced are found to be +0.182, +0.163 and +0.211 for the total, Tamworth and Berkshire litters respectively.

Data from a larger number would be more reliable but it is believed that the numbers available in this investigation were large enough to have some significance. While the correlation coefficients are not the same for Tamworths and Berkshires they are similar in so far that they are all so low that no significant correlation is indicated in any case.

This study does not give much support to the theory that pigs from large litters consistently produce large litters.

✦

A Biologist Views the Universe

THE three parts of this book* are based on the tenth series of lectures on religion in the light of science and philosophy. The purpose of the lectures is to present a positive outlook on life and the world as given by a study of biological science. This book offers as the religious objective of man the genetic improvement of the human race. The author holds to what is called the emergent view of evolution, that in the appearance and development of life something fundamentally new has appeared that could not be predicted by means of reasoning and computation from the existence and properties of the fiery mist of the early history of the world. Sensations, emotions, purposes, ideas, and ideals were not existent in a world of particles, velocities, directions, and distributions. Only at a later period did they come into existence. Laws governing sensations were not complete in earlier times but are now.

Because a mental state and its characteristic accompanying physical condition are inseparable, mental states are concluded to have an effect on action. The earliest and simplest forms of life did not experience emotions and ideals. These came into existence later. The universe is continuously creative now as in the past. Since the universe changes with the passage of time, yielding new phenomena and new methods of action, science can never be finished. Advancement of life may (or may not) be through man in improvement of his intellectual faculties. Life is on a new adventure, moving in directions not laid out beforehand, transforming into what did not before exist, rising to heights not before reached. Right and wrong are considered as qualities of actions as they affect successful living, for the individual and his associates. Only experience discovers what things in life are of value. No maxim or body of maxims can guide one in detail under all the complexities of life. The problem of conduct must be solved on the basis of the promotion of higher types of life. Respect and sympathy for the lives and interests of all mankind are demanded. The objective of the biologist is the promotion of the adequacy of the generations that continue life and the evolutionary development of that life. This includes improvement of the conditions of life, of knowledge, invention, hygiene, social organizatiton and of the living material of life, the coming generations.

Certainly the church, which has been a great factor in the promotion of higher education and of research, and which has recognized the relation between inheritance of superior mental and moral qualities and high spiritual development, will heartily subscribe to much of Dr. Jennings' reasoning.

G. M. Darrow
U. S. Department of Agriculture

*Jennings, H. S., *The Universe and Life.* Price, $1.50. Yale University Press.

TOO FEW FINGERS—AND TOO MANY

Some Notes on Genes and Pigs-Feet-in-the-Diet as Agents to Produce Digital Abnormalities

THE purpose of this note is to put on record two cases of deviation from normal hand form. One of these presents photographs of a Spanish family which illustrate the inheritance of syndactyly as a Mendelian dominant character. The other is an object of genetic curiosity chiefly as a horrible example of that perennially recurring absurdity, "maternal impressions." Some years ago an article in the JOURNAL very effectively debunked this subject. This we have rather frequent occasion to cite as the most convenient way to dispose of succeeding crops of this absurdity. For a time it seemed that maternal impressions might go permanently out of style, but recently the myth has revived as a curious by-product of the N.R.A., and elsewhere, as in the case cited below. The return to popularity of this quaint superstition may indicate that it is time to go on the warpath once more to keep the human race from being too much desolated by a wave of the astonishing prenatal deformations for which this phenomenon is held responsible.

A Lobster-Claw Family

The literature of syndactly has recently been reviewed in the JOURNAL,* and the reader can obtain there other references to this defect. Information regarding the family illustrated in Figures 13-15 was obtained from the Spanish magazine, *Estampa,* for November, 1933. This article is in the form of an interview with the mother, and it appears to be unquestionably authentic. The facts which are not confirmed in the photographs are presented in a form that leaves little doubt of their validity.

The family, named Vitores, lives in the small village of Pedreza de Campos. The father is an unskilled laborer, who has found the problem of existence in a depressed world difficult and precarious. At the time the photographs were taken he was about thirty-seven and his wife thirty-four years old.

The wife has only four fingers on each hand, as is shown in the illustrations. She has found this a rather serious handicap in the manual details of housework, but has with practice and perseverance become adept in the use of her fingers.

She is stated to have had seven brothers and sisters whose hands were completely normal, although she had the defect at birth. Her mother's hands (Figure 14) are normal. No statement is available regarding the condition of the hands of the mother's father.

The tally of normal and defective children in the Vitores family is as follows:

1. A girl, about twelve years old at the time the photographs were taken; defective hands, feet normal.
2. A boy, died in infancy; hands and feet defective.
3. A boy, died soon after birth; normal.

4-5. Twins (boy and girl); both with hands defective, the boy with feet defective.

6. A boy; hands defective, feet normal.
7. A boy; hands and feet normal.

Thus the genetic ratio of syndactyl to normal, 5:2, is a considerable departure from the 1:1 ratio expected in the cross of a heterozygote to the recessive.

The extreme variability of this character is perhaps a clue to its sometimes sporadic appearance. In the same family will be found individuals who are defective only to the extent of webbing between two fingers, and others in which the hand is reduced to the extreme lobster-claw form. The milder types of syndactyly may give rise in their progeny to the extreme forms. Why does the character show such marked varia-

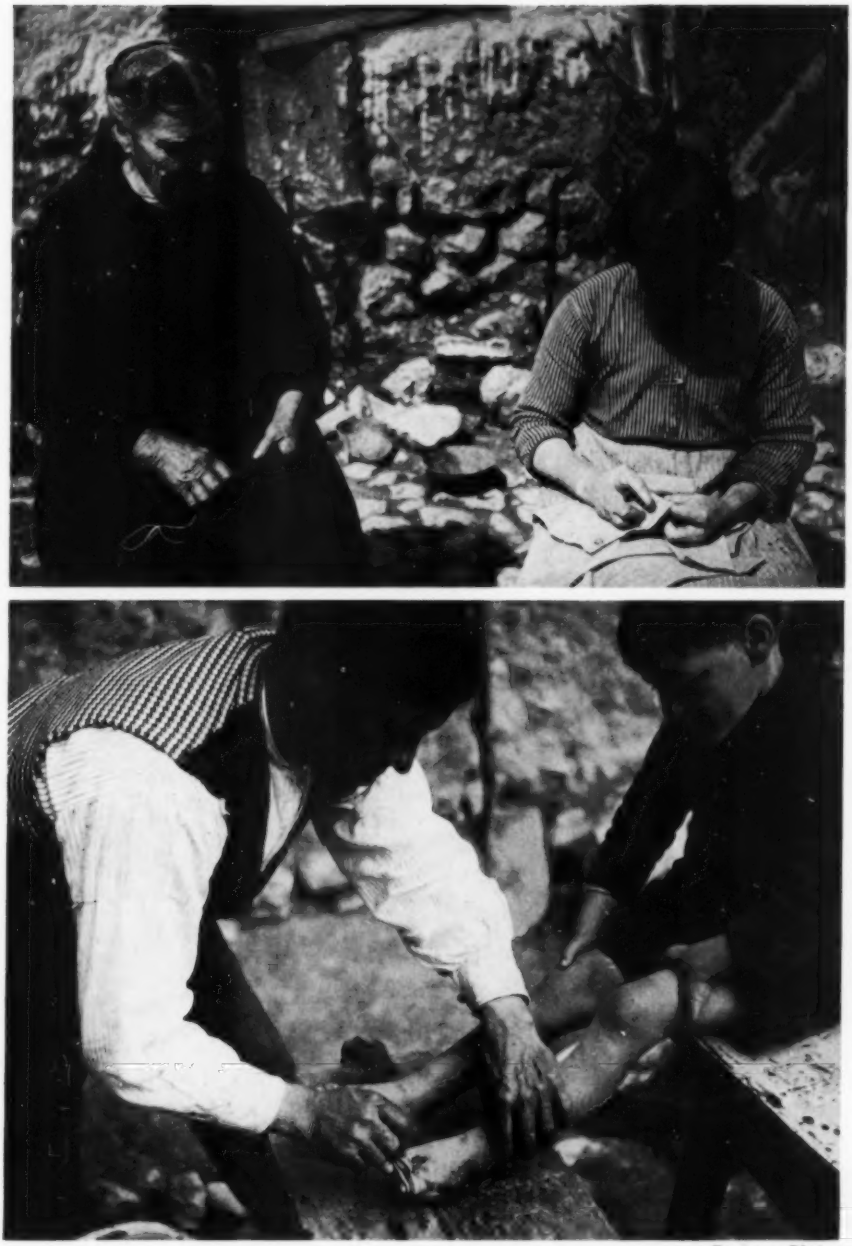
* SCOTT, W. 1933. Syndactylism with variations. *Journal of Heredity,* 24: 241-243.

European Photos

A STUDY IN FUSED FINGERS

Figure 13

Four Vitores children who show varying degrees of syndactyly. The mother had the defect in a rather mild form (see opposite page), and five of her seven children show syndactyly to an equal or greater extent.



European Photos

THREE GENERATIONS OF FUSED FINGERS

Figure 14

The grandmother's fingers (upper left) are normal; the mother (upper right) has only four fingers on each hand. No information is available about the mother's father, but all her brothers were normal. The husband (lower left) has normal fingers. The fourth and fifth children (twins) were both syndactyls, and the boy twin (lower right) also has defective feet.

European Photos

SEGREGATION OF SYNDACTYL GENES

Figure 15

This illustration is of special interest because it shows the one surviving child with normal fingers. The third child also was unaffected, but died in infancy. The photograph also gives a hint of the manual difficulties in handling tools which, in addition to the emotional reactions, may render this defect a continuing tragedy to those who manifest it. Syndactyly is a dominant Mendelian character which shows very wide variation in the extent of its expression.

tion? A most likely assumption is that modifying factors are involved which tend to alter the dominance of the lobster-claw gene. If this is the case, we can see why the milder forms of syndactyly may be intensified in the next generation, and we can even imagine that two additional steps may be included in the same series. At one end we might have complete recessiveness, in which a person carrying the syndactyl gene would not show it, and at the other, it is possible that the defect in its extreme expression may involve complete absence of the hands and feet. A few years ago a case of this kind was reported from Brazil, in which the hands and feet of a family of several children were entirely missing —the appendages terminating in mere stumps. This might represent the lobster-claw gene *and* the "plus modifiers," both in homozygous condition.

In any event the theoretical considerations regarding the inheritance of the defect are rather outweighed when we think of its effect on the individual in a specific instance, as in the Vitores family. The excellent physical development of the children in this family in all other respects than their defective hands, even adds to the pathos of this case. From the interview published in *Estampa* it appears that the parents were overwhelmed to discover that the defect in the mother's hands appeared in all but two of her children, and in some of them in an intensified form. They appreciate fully the continuing emotional tragedies which are almost certain to occur as a by-product

of this defect. Further than this, they are evidently not indifferent to the added hardship and increased difficulty of making a living.

Under these circumstances it would seem that a voluntary sterilization law tactfully administered might have served to avert much tragedy. Virtually the same situation exists with many hereditary defects in man, when we stop to consider them not only as case histories but as human documents. In many instances (as one suspects might have been true in this case) compulsion would not be necessary to end these continuing tragedies if the matter were tactfully and sympathetically presented to those who are in better position than anyone else to realize most keenly what suffering is to be avoided by having a less numerous progeny.

A New Deal in Maternal Impressions

One wonders to what extent the maternal impressions myth may owe its continued popularity to the challenge it offers to the imaginative faculty to discover alluring *ex post facto* "reasons" for every deviation from normal development observed in man or beast. When the Blue Eagle first spread its beneficent wings over this troubled land, only a few weeks elapsed before babies began to arrive neatly stamped with General Johnson's favorite fowl, almost down to the inspirational motto "We do our part." It has been something of a continuing nomenclatorial tragedy that parents have long shown a deplorable tendency to label helpless infants of each rising generation with the cognomen of the political (or other) hero popular at the moment of birth. It is bad enough to have to pass through this vale of tears thus an etymological twin to some forgotten politico, but if this new trend in maternal impressions becomes popular, and if the fad of symbolical swasticas, hammers, and birds of doubtful genus continues to increase, the future of the human epidermis appears gloomy indeed. The only hopeful thought is that as this tendency wears itself out it will eventually lead to a mere incoherent symbolical blotching of the skin. This, the best advertising opinion leads us to hope, cosmetics and yeast in abundance may remove, so that the future prosperity of these industries, at least, may be assured.

TOO MANY PIGS-FEET IN MOTHER'S MENTAL DIET!

Figure 16

"Photographic evidence" again establishes that brooding over this and that on the part of expectant mothers produces something else again in the form of daughter's hands,—believe it or not!

Unfortunately, we were able to obtain no authentic photographs of the "babes of the Blue Eagle," but the illustration reproduced herewith is put forward as "photographic proof of marking." As one more example of inventive genius in accounting for a not extremely rare deviation from the normal, it perhaps deserves brief record.

It seems that Mrs. Potvin of Ottawa, Ontario, had to prepare for the Potvin family, during the months before Yvonne's birth, large quantities of pigs' feet for stew. She took an increasing dislike to cleansing and scraping the hairs from between the toes of this delicacy, and it preyed on her mind continu-

ally during the time of her pregnancy. She was, therefore, not surprised when Yvonne appeared on the scene with a double thumb on the right hand. Doubtless further inquiry would develop the fact that Mrs. Potvin was right handed, and it was the extra activity of this hand in this detested occupation which produced the "marking" effect. None of Mrs. Potvin's other children had such a defect. Whether the Potvin diet of porcine extremities was indulged in only during this period prior to Yvonne's birth does not appear in "the record."

This linkage between the culinary and reproductive arts would appear to deserve further consideration. What would have happened had the Potvin family indulged in a prolonged debauch of oxtail soup? Had the expectant mother been unable to avoid the contemplation of tripe instead of pigs' feet, would we have had a Yvonne with hands modeled after "vacuum cup" tree-frogs' toes, or reminiscent of popular brands of automobile tires? Suppose Papa Potvin had brought home a bushel of oysters at an opportune moment—what then? If Yvonne's mother had as much trouble opening them as the writer does, it is to be feared that Yvonne's temper as well as her hands might have had a bivalve configuration. But an end to such solemn speculations. They, like the "explanations" of existing "maternal impressions," might go on indefinitely and to as little purpose.

The duplication of digits has been considered to represent an initial stage in the twinning process. The various stages in the transition from mere six-fingeredness to complete Siamese twins and to two entirely separate individuals have been held to be steps in a related process. In some families the production of extra fingers is definitely inherited as a dominant character. In other cases polydactyly is sporadic in its appearance, and a recessiveness or multi-factor complications are suggested. R. C.

THE GROWTH OF THE CHILD

(*Continued from page* 450)

genes, the structural basis of behavior types, the somatic constitution, developmental correspondence in twins, and on inherited behavior traits. Stockard's experimental work on the inheritance of somatic constitutional and of certain temperamental and behavior characteristics in dogs is cited as supportive evidence that specific pattern trends may be transmitted by these processes.

A formulation of some principles of developmental diagnosis of infant behavior is presented in the last chapter. A few of these statements will serve to indicate the general trend of the conclusions:

> The growth characteristics of the infant are primarily determined by hereditary and constitutional factors, which undergo their basic organization in the uterine period. * * * These factors do not operate independently of postnatal environmental influences, social and physical, but they determine the direction and scope of such influences. * * * * Maturational factors impart characteristic trend, tempo and general configuration to the early behavior patterning of the individual. * * * * Mental growth is an orderly process of morphogenesis. The reaction system of the infant is a unitary structure which manifests itself in specific and correlated patterns of behavior.

The material obtained by observation in this study is voluminous and has been tabulated in minute detail; which is a desirable feature in investigations organized to show structuralization in the growth of behavior. In a forthcoming volume, entitled "Norms of Infant Development," the authors "will set forth in monographic detail the basic data of the normative survey, the specific procedures used in the developmental examinations, and biometric conclusions and applications." These studies have been needed for a long time and should prove helpful to those interested in human behavior and particularly to those workers engaged in the clinical study of children.

N. D. C. Lewis
St. Elizabeth's Hospital

SYSTEMS OF PLANT CLASSIFICATION

A Review

OF the making of botanical systems there appears to be no end; and the effort, if of no great value to humanity at large, is, after all, less harmful than the making of certain other systems which have occupied much of the world's time during the last twenty years. The latest author to attempt a rearrangement of flowering plants is Dr. John Hutchinson of the Royal Botanic Gardens at Kew, whose work,* under the title *The Families of Flowering Plants,* is published in two volumes, devoted to the Dicotyledons and Monocotyledons respectively. Unlike some recent efforts of this sort, this is not a mere intellectual tour-de-force based on the volumes of Bentham and Hooker and of Engler and Prantl, but a serious attempt, on the part of a botanist as familiar with the plants themselves as with the books describing them, to arrive at an approximately natural system representing as nearly as may be the likely course of evolution. The ground plan for this he finds better presented in the system of Bentham and Hooker, worked out solely to represent the relationships of plants as indicated by their structural characters without thought of evolution, than in that of Engler and Prantl, which was primarily intended to be an evolutionary scheme. Thus do classifications like other matters revolve in circles. The Ranunculaceae and Magnoliaceae, considered by De Candolle to typify the "perfect" flower because of the relatively large number of free parts in each series, and, accordingly, placed at the head or beginning of the system, are now by the very same structure considered to be the most primitive and placed at the foot, but in the same position. And if the Apetalae, placed as a terminal group of Dicotyledons by Bentham and Hooker but broken up and variously distributed by Hutchinson, are omitted from consideration, his system of the Dicotyledons is found to follow in a general way that of Bentham and Hooker and to end like theirs with the mint family (Labiatae), again differing decidedly from that of Engler and Prantl. In the details by which the framework is filled in, however, Hutchinson's scheme differs widely from both the earlier systems. The Monocotyledons are considered to be derived from the Dicotyledons and are placed after them, thus having the same position assigned them, for a different reason, by Bentham and Hooker; and the Gymnosperms, unfortunately interposed by Bentham and Hooker between the Dicotyledons and the Monocotyledons, are considered to be not true flowering plants and are omitted from consideration. All flowering plants, Monocotyledons as well as Dicotyledons, are derived from a primitive base represented by the present-day Ranunculaceae and Magnoliaceae.

The Existing Systems

The factual basis of all subsequent systems of flowering plants is the *Genera Plantarum* of George Bentham and Joseph Dalton Hooker, published in three thick volumes from 1862 to 1883, and based on the unrivaled collections at Kew. The main divisions of their classification trace back to De Candolle (1818), but the details of family and generic relationship, as well as alterations in the composition of some of the larger groups, are their own. Their firsthand elaboration and full description of the systematic characters of the families and the more than 8,000 genera of flowering plants brought together a body of exact information which has lost comparatively little of its value in the course of half a century. It is still the work to which most students of other than local floras turn for the identification of an unknown plant, and equally the primary source of generic and family descrip-

* HUTCHINSON, JOHN. *The Families of Flowering Plants.* I. Dicotyledons. Arranged according to a new system based on their probable phylogeny. 1926. xiv, 328 p., 264 fig., maps, table. ($6.00.) II. Monocotyledons. 1934. xiii, 243 p., 107 fig., maps. ($6.00.) Macmillan & Co., New York.

tions for writers of floras of almost any part of the world. Its publication begun only three years after the publication of Darwin's Origin of Species, it remained essentially uninfluenced by the then strongly debated theory of evolution, in this respect contrasting strongly with practically all later systems, for they have made the attainment of a natural, that is, evolutionary, system a principal aim. Presumably the secret of its continuing value is to be found in this very fact.

Only four years after the completion of Bentham and Hooker's work, Adolf Engler and Karl Prantl published the first part of *Die natürlichen Pflanzenfamilien*, the first edition of which, completed in 1909, fills the average bookshelf (the vascular plants alone). It was conceived on a scale far beyond the powers of any two men, but its authors, by enlisting the services of many botanists (practically all of whom were Germans), finally covered the whole plant kingdom. The full descriptions of the structural characters of genera, which form the main substance of Bentham and Hooker's work and give it its permanent value, were replaced in many or most of the families by brief diagnoses, based for the most part on Bentham and Hooker's work, and supplemented by keys. On the other hand, brief accounts of the anatomy, the variation of floral and other parts, and some other general subjects not considered by Bentham and Hooker were given for each family, the principal economic plants were mentioned, and the work was freely illustrated. In spite of its evolutionary bias the work is happily free from the hypothetical family trees, like deformed hat racks, which nowadays seem to be considered an essential item in any revision or descriptive account of a botanical group that is not monotypic. The general outline of Engler and Prantl's classification was derived from Eichler (1836-40), but with many changes of greater or less extent.

New Taxonomic Bedfellows

Too much space would be required for a discussion of the many details in which Hutchinson's arrangement of the Dicotyledons differs from those of Bentham and Hooker and of Engler and Prantl, but two general distinctive features should be mentioned. One is his disposition of the rather numerous groups with apetalous flowers. These were segregated (36 families) by Bentham and Hooker as their third large group of Dicotyledons (Monochlamydeae), coordinate with the Polypetalae and Gamopetalae, and placed at the end of the class. Engler and Prantl, considering them, in general, on the basis of their relatively simple flowers, the most primitive, put most of them at the beginning of the Archichlamydeae. They did not separate them under a group name, however, and distributed a few elsewhere through their system, next to the families to which they were considered most closely allied. Hutchinson, completing the disintegration of the group long ago initiated by A. Brongniart, scatters them among numerous alliances throughout the Archichlamydeae, on the basis of their supposed relationships, deriving most of them from the Rosales, Caryophyllales, and Ranales. In an introductory note (p. 4), he suggests that a similar procedure should perhaps be followed with the Gamopetalae.

The second distinctive feature of Hutchinson's arrangement of the Dicotyledons, and the most original, is his attempt to distribute them along two chief lines, one predominantly woody, the other predominantly herbaceous, derived respectively from the Magnoliales and Ranunculales. This plan is represented clearly in his phylogenetic tree, although difficult to follow in the necessarily lineal arrangement of orders and families in his text. Apart from the fact that woody or herbaceous habit is, in many cases, obviously correlated with habitat, it must be borne in mind that the respective percentages of woody and herbaceous forms among the living members of a family are not necessarily representative of the situation existing at the origin or during the early development of the family. Moreover, Hutchinson's disposition of some families on this basis is apparently incorrect. Thus, in his introduction (p. x), the example given to demonstrate

the utility of this grouping by woody or herbaceous nature concerns the separation of the "Flacourtiaceae (woody) and the Violaceae (mostly herbaceous)," which had previously been associated on account of their parietal placentation. It is true that the representatives of the Violaceae familiar to the botanist of the north temperate zone are likely to be herbaceous members of the genus Viola. The family, however, is largely a tropical or subtropical one, represented in the second edition of Engler and Prantl (Melchior, 1925) by 16 genera, of which 14, containing 324 species, are always woody, and only two (Viola and Hybanthus, containing together 475 species) are usually herbaceous. Obviously the family as a whole cannot be considered predominantly herbaceous.

Owing to the fact that Hutchinson's grouping of orders into higher alliances is indicated only by cross lines in his conspectus (p. 10-28), without indication of the features on which these higher groups are based, it is impossible to get far with their discussion. An analysis of the woody or herbaceous nature of the 264 families recognized by Hutchinson in the Dicotyledons may, however, throw some light on the significance of his grouping on the basis of this feature. Proceeding, then, on the basis of the family characters given by Hutchinson, with some resort to Bentham and Hooker and to Engler and Prantl in doubtful cases, we find that of 264 families, 141 (53%) are always woody and 33 (just ⅛ of the whole) always herbaceous; of the latter, 6 are practically entirely aquatic, 4 (of which 3 are insectivorous groups) are restricted to swamps and marshes, and 5 are entirely parasitic or saprophytic, leaving only 18 strictly herbaceous families of essentially normal mesophytes (and of these 2, Saururaceae and Lentibulariaceae, are mostly aquatic or of wet places). Of the remaining 90 families (just over 1/3 of the whole number), 19 are almost entirely woody and 22 almost entirely herbaceous, while 49 families (nearly 20% of the whole), although often predominantly woody or herbaceous, nevertheless contain enough representatives of the minor group to make them properly classed as mixed groups. Combining the figures, we find that 160 families are woody with very rare exceptions, 55 herbaceous with equally rare exceptions, and 49 mixed. Combining them in still another way, we have 231 families containing woody plants and 123 containing herbaceous forms. Once more combining them, we find 141 always woody families and 123 that are at least sometimes herbaceous; or 33 always herbaceous and 231 at least sometimes woody. It is evident that, on the basis of family grouping, among the Dicotyledons, woody plants considerably outnumber herbaceous forms, perhaps in the ratio of 2 to 1. An analysis of genera on the same basis would be of interest, but is far outside the scope of this review.

Of the 76 orders of Dicotyledons recognized by Hutchinson, 18 are entirely woody and 3 entirely herbaceous (Sarraceniales, Podostemonales, Plantaginales); 13 are very largely woody and 7 herbaceous; and 35 are fairly well mixed. Combining these figures, we find 31 orders largely or entirely woody, 10 largely or entirely herbaceous, and 35 mixed. Of the total 76, 73 are at least sometimes woody and 58 at least sometimes herbaceous.

Closer study of the composition of individual families and orders might result in placing some of them much more definitely, on the basis of internal evidence, in either the woody or the herbaceous group. However, the figures given are sufficient to show, in connection with the comparative indefiniteness of the distribution of woody and herbaceous groups through his system, that the variability of habit in both families and orders is so great as to render his attempt to divide the Dicotyledons primarily on this basis unfounded and hopeless.

Monocot Taxo-Mutations

It is in his treatment of the Monocotyledons that Hutchinson departs most widely from the systems of Bentham and Hooker and of Engler and Prantl. Engler and Prantl arranged their monocotyledonous groups, as they did the Dicotyledons, on the general basis of ad-

vance in flower structure from the simplest forms with indefinite perianth to those in which the perianth is most highly developed, the orchids. The lineal arrangement in Bentham and Hooker was, in a general way, pretty nearly the reverse of this. In the Monocotyledons, as in the Dicotyledons, Hutchinson in general regards very simple flowers as reduced rather than primitive, and so assigns a much higher position to them than did Engler and Prantl. He takes the most primitive forms to be the Butomales (Butomus, flowering-rush) and Alismatales (Alisma, water-plantain), and moreover regards these two orders as very closely allied respectively to the subfamilies Helleboroideae and Ranunculoideae of Ranunculaceae. The Monocotyledons as a whole he divides into three principal groups. In the most primitive of these, the Calyciferae, the perianth is biseriate with free green sepals and free colored petals; the base of the plant is usually a rhizome, never a corm or bulb. This line includes the Butomales, Alismatales, spiderworts, and bromelias, and culminates in the gingers (Zingiberales), a group in some respects paralleling the orchids. A subsidiary line of simplified aquatic groups includes the pondweeds, eelgrass, and various small families. The second big series, the Corolliferae, with the two primitive whorls of the perianth more or less similar and uniseriate and with a tendency to the development of a bulbous or cormous base, branches out in several directions, one leading from the lilies to the orchids, another through the agaves, the palms, and the screwpines (Pandanus) to the Cyclanthaceae, and another to the orders represented by yam (Dioscoreales), alstroemeria, amaryllis, iris, cattail, and aroids. The third principal group is the Glumiflorae, including the rushes (Juncales), the sedges, and the grasses. The Glumiflorae are considered to be a much reduced climax group, and the grasses displace the orchids as the highest type of Monocotyledons, at least in so far as this can be represented by a lineal arrangement.

The most controversial change made in the Monocotyledons is the newly proposed criterion for the separation of Liliaceae and Amaryllidaceae, which have always hitherto been not too well distinguished by the position of the ovary (superior in the former, inferior in the latter). The Amaryllidaceae, here constituting the order Amaryllidales and separated from the Liliales by the interposition of the Alstroemeriales, Arales, and Typhales, are characterized by their umbellate inflorescence of one to many flowers, subtended by one or more spathaceous bracts. The Liliaceae, by contrast, have the flowers "never in umbels." On this basis, several groups with superior ovary hitherto referred to the Liliaceae are placed in the Amaryllidaceae, namely Agapantheae (African-lily), Allieae (onions and their allies), and Gilliesieae. Whether this single habit character will prove more satisfactory than the single more technical character offered by the position of the ovary remains to be determined. It is not without exceptions in the Liliaceae, even as restricted by Hutchinson. Thus in the tribe Johnsonieae the flowers are "in terminal heads or umbels," in the Iphigenieae "racemose to capitate or subumbellate," in the Massonieae "crowded in a subsessile head surrounded by three or more bracts," and in Clintonia, placed in the tribe Polygonateae, they are definitely umbelled, at least in some of the species.

Other Possibilities

Enough has been said to indicate the general character of Hutchinson's classification as compared with that of Bentham and Hooker and of Engler and Prantl. His volumes represent a serious attempt to combine the best features of the two principal current systems and to add the results of more recent investigations of the relationships of families, particularly those that are to be considered reduced rather than primitive. In the absence of any worth-while fossil records of the great mass of flowering plants, however, such attempts are bound to be largely subjective. No doubt the next author willing to spend as much time and trouble will produce a very different system, equally plausible and

equally uncertain. Comparing Hutchinson's evolutionary trees with those of other authors, one is inclined to say with the poet:

"Enough to think such things may be: to say they are not or they are
Were folly * * *"

A botanical system, to win adoption, must serve several purposes. Its primary uses are practical ones—the identification of plants down to the genus (the naming of species, in general, is a matter for monographs and local floras), and their arrangement in herbaria and in published floras. In addition, it should provide a grouping of families into orders and higher divisions that approximates nature as nearly as possible. The botanical families now generally accepted are almost without exception natural and definable concepts; their grouping into orders and higher alliances and the lineal arrangement of these are matters of individual opinion. A scheme which merely rearranges or recasts the families and orders, whatever value it may possess as a contribution toward an ultimate complete new system, should not be taken as a basis for changes in herbaria or in published floras. To arrange families according to one author and genera according to another would serve no useful purpose. Bentham and Hooker's chief groups were no doubt artificial, but were at any rate definable without too numerous exceptions. The orders of Engler and Prantl were mostly not very clearly defined, but were fastened along the thread of increasing floral complexity in such a way that the student could follow the assumed path of development and guess with some assurance the approximate position of a given plant. The system proposed by Hutchinson may very well represent a closer approach to the true relationships of flowering plants than either of the earlier systems, but it fails for the most part to characterize the groups above the rank of order, it is too involved to be grasped without prolonged study, and the highly hypothetical nature of some of the new associations suggested does not favor its immediate and unqualified adoption. The work is likely to find its place as a convenient and up-to-date summary in English of the characters of the families of angiosperms rather than as the realization of a new system of classification. The needed new system must be based on more than the structure of the flower and the duration of the stem. Until it is provided, adherence to the order of one of the two older and completely elaborated systems for the arrangement of herbaria and floras is certainly advisable.

It remains to add that the volumes are well printed and illustrated and exceptionally free from typographical errors. The very satisfactory figures, by Dr. Hutchinson and by W. E. Trevithick, are partly original but mostly copied from other works. In the volume on Dicotyledons, one species in every family is represented; in that on Monocotyledons, a few families are not represented, while several figures are given of some of the larger families. In choosing subjects for illustration species not figured in the ordinary text books have almost always been selected. Small distributional maps are frequently added. Each volume contains a phylogenetic chart and an artificial key to families, that to the Dicotyledons covering 50 pages. These keys appear to work well in practice and should prove a very useful feature of the work. In the Monocotyledons, space has permitted the insertion of very brief and compactly printed keys to genera in all families except the Orchidaceae and Gramineae; that to the Palmae, however, is incomplete. The treatment of the Gramineae is by C. E. Hubbard, that of the Hydrocharitaceae by J. E. Dandy. Altogether, Dr. Hutchinson is to be congratulated on the completion of a very convenient and useful, if by no means final, work on the families of flowering plants.

S. F. Blake
Bureau of Plant Industry

THE FUNDAMENTALS OF CYTOLOGY

IN attempting to produce a text suitable for beginning students in cytology and for the general biological reader, the author of this well written and beautifully illustrated book has recoiled vigorously against the all but universal tendency among Germanic authors toward exhaustiveness of treatment, and has written in consequence a text shorn of unessential features, reduced to bare fundamentals, and restricted in scope to the fields of morphological cytology and cyto-genetics.*

In reacting thus vigorously, however, from the prevalent compilatory tendency of German text-book writers, the author has gone to the opposite extreme, and has omitted much which would seem to the reviewer essential or highly desirable in an adequate text. Thus, there is an almost total lack of bibliography, and of reference to specific authors and their contributions; the various facts and hypotheses are usually presented without reference to the sources whence they have been gleaned or to the workers who are responsible for them. This would seem to encourage an unscholarly and uncritical attitude on the part of the beginning student, who should be encouraged to adopt a critical attitude toward facts categorically presented, and to seek out original sources as a means of satisfying himself of the correctness of these facts. It is to be feared that a student using this text would not be encouraged to explore in the field of cytology, but rather to take on faith the facts and conclusions presented.

A result of this almost complete lack of reference to original sources is that the subject matter is presented as a crystallized body of proved fact, and is not as a rule treated developmentally. Historical background and perspective are lacking. The student, therefore, who would know how facts have been obtained, or how the evidence has been acquired upon which certain hypotheses are grounded, will find little to aid him in this book.

Apart from these faults, the text has much to recommend it. It is concise, clear, well organized, splendidly illustrated, up to date. It is especially to be recommended to readers in English as containing a fuller treatment of the cytology of the Protista than can be found in other works. This is a field in which the author is especially an authority. The chapter headings are as follows: cell morphology, cell division, nuclear division, fertilization, chromosome reduction, cytology and genetics. A short appendix contains a discussion and description of certain rapid cytological techniques. There is a short subject index, but the bibliography consists only of a list of eight recent textbooks in cytology.

RALPH E. CLELAND

Goucher College.

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STATISTICS FOR SOCIAL SCIENTISTS

THE primary purpose of this book† "is to derive formulas and computation schedules that will simplify as much as possible effective, practical trend analysis." The book is written primarily to facilitate the analysis of data in the social sciences. It is divided into three sections, namely: (I) Fitted polynomials in trend analysis, (II) Trend determinations by data sums and averages, and (III) Analytic trend fitting by general systems of polynomials. The mathematical basis of the different methods of trend analysis are discussed in detail. A great many illustrations of actual computations are given.

F. R. IMMER

University of Minnesota

*GEITLER, L. Grundriss der Cytologie. 295 pp., 209 ill. Berlin: Gebr. Borntraeger. 1934.

†SASULY, MAX, *Trend Analysis of Statistics.* The Brookings Institution, Washington, 1934.

A VIABLE TWO-GENE DEFICIENCY

Phaenotypically Resembling the Corresponding Hypomorphic Mutations

H. J. MULLER*

Institute of Genetics, Academy of Sciences, Moscow

On the Lethality of Previously Known Deficiencies

ON THE conception of the germ plasm as a stupendously complex system of thousands of interacting genes evolved through the natural selection of accidentally advantageous mutations, it is logically to be expected that each individual gene should itself have undergone a complex evolution involving numerous selected mutations whose effects have in part served as a basis for the effects of selected mutations in other genes and that its removal would therefore usually derange the workings of the entire system in various ways (Muller,[12] p. 463-464). Whether such removal would usually be so detrimental as to be lethal could scarcely be predicted in advance, any more than it could be predicted in advance of considerable knowledge of its function, whether or not the removal of a particular organ from the human anatomy would usually involve fatal consequences. A lethal effect is not so inevitable as it might seem at first sight, for the organism is not merely a complex system with many interlocking parts, interdependent in function like those of an ordinary machine, but through natural selection, it has developed many spare parts, as it were, or at least partially spare parts of overlapping functions. That is, it has available to it many processes of regulation and compensation that may be called into action in cases of disturbances of the normal equilibrium, including among the latter even changes that are genetic in origin. Nevertheless, it is not to be expected that the organism could withstand the effects of the removal of many genes at once, just as it could not usually survive the removal of many organs at once.

In judging of the degree of injury to be expected, we should bear in mind the *a priori* principle that, for an organism of given complexity, the less numerous the genes are, the more complex must each individual gene necessarily be and the more essential in the vital economy, and the effects of its removal would be correspondingly more dangerous. On the basis of general considerations regarding the very high complexity of the organism as a whole and of its germ plasm, and an estimate of the number of genes as lying somewhere in the thousands, the author in his discussions with other geneticists has long advocated the view that most ordinary deficiencies, involving an appreciable section of the linkage map, and not compensated for by duplications (either by those of recent origin or by those which had become established in the earlier evolution of the genus), should be clearly lethal, but he has withheld from formulating a prejudgment as to how often the removal of a single gene should be lethal to the zygote. Obviously, however, such zygote-lethal effects should be considerably more frequent than effects which are lethal even to individual cells or groups of cells living more or less independently or administered to by normal surrounding tissue.

Bridges' work on non-disjunction proved the lethality of the absence of the entire X chromosome and likewise of the fourth chromosome (when neith-

*Professor of Zoology, University of Texas; guest at Institute of Genetics, 1933-35. Originally transmitted for publication Nov. 22, 1934.

er fourth chromosome is present), and both his work and Mohr's extended this conclusion to the forked-Bar deficiency and the Notch-8 deficiency, respectively, neither of which was more than a few units long. Since then other deficiencies have been found, all of which have proved to be lethal. To be sure, these deficiencies were not at the time proved to involve actual absences of chromatin, but, as shown in a parallel paper on the case of scute 19, there is now every reason to conclude that they were really of this nature. In the case of scute 19 the absence of chromatin has been definitely proved, both genetically and cytologically. The region lost here is considerably smaller (including perhaps only four genes in all) than that involved in any of the hitherto known deficiencies that were demonstrated to include more than one locus, and here too, the effect is lethal to the zygote.

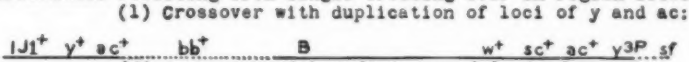
Examining some of the earlier cases of chromatin absence, Li found that the deficient individuals always died off in the egg stage, that is, very early in development. This was of course to be expected, and such cases form a contrast to many though not all cases of lethal "gene mutations," as first directly demonstrated in the work of Sivertzev-Dobzhansky. This very early lethal action is of course to be interpreted as in the main a cell-lethal effect, since the cells of the early embryo are able to live with as yet little dependence upon one another. This then affords an illustration of the comparatively high complexity and evolutionary elaboration even of the processes of individual cell metabolism, and of the lack of stored gene-products in the cytoplasm that can suffice for more than a few cell-generations of the embryo.

In some recent communications, giving the results of parallel work, Demerec and Stern each describe cases in which known or suspected deficiencies of portions of a chromosome are lethal to somatic cells or groups of cells, developing amidst normal tissue. In Demerec's work, which was more directly concerned with the problem here in question, 24 cases of this type were studied. In explanation of the method, it may be recalled that Patterson[20] had found that, when a female has its two *X*-chromosomes differentiated by markers for epidermal characters, such as yellow and singed, twin spots (yellow and singed, respectively) lying next to each other, are produced by the somatic segregation of these *X*'s from one another in a dividing larval cell. In Patterson's cases this segregation was induced by X-rays, but Stern (reinterpreting earlier work of Bridges and himself on supposed "elimination" of chromosome parts) finds this segregation to occur even without treatment in flies of certain "Minute bristle" types; he interperts the process as one of somatic crossing over. Absence of one member of the pair of twin spots thus produced indicates a lethal effect of the chromosome in question on the cell or group of cells containing it. In Demerec's experiments five chromosomes carrying known deficiencies of more than one locus all proved to be lethal when thus tested. Of 19 other cases, known to be lethal in their effect on the whole individual but not known to involve more than one locus, all except those (4) involving the locus of "cut wings" were likewise lethal to the cells containing them. Demerec concludes from this that deficiencies of a single gene probably have a cell-lethal action in the great majority of cases.

Unfortunately we do not know which of the latter 19 cases were real deficiencies, nor, in these or the previously proved deficiencies, how many genes were missing. Hence the interpretation of the results must remain in question, though no doubt studies by the new cytological method of Painter will be of service here. Certainly not every mutation that is lethal to the whole individual is a deficiency and so it is quite possible or likely that the cut-lethals were not deficiencies at all. On the other hand, it is also quite possible (contrary to Demerec's opinion) that most of the *other* cases involved de-

Synapsis of X chromosomes in individual heterozygous for $sc^{8}w^{a}B$ and y^{3P}:

Chromosomes resulting from single crossing over in region between B and w^{a}:
(1) Crossover with duplication of loci of y and ac:



(2) Crossover with deficiency of loci of y and ac:

HOW THE DEFICIENCY WAS PRODUCED

Figure 17

Diagram showing synapsis of X-chromosomes in individual heterozygous for $w^{a}B$ y^{3P}. Crossing over in the region between *B* and w^{a} produces either duplication or deficiencies of loci for *y* and *ac*. By this means it is possible to obtain individuals deficient for only two genes. These were viable. (Exponent+ designates normal allelomorphs; "sf" designates locus of spindle fibre; dotted line represents inert regions.)

ficiencies of sizeable sections that included several genes.* We do not hold with Demerec that the ease with which the Bar gene is apparently "knocked out" without a lethal effect can be used as a criterion to show that in the case of other loci also a single-locus loss is more frequent than that of two or more loci; in fact, Demerec's own data on double-Bar and on garnet deficiencies prove that in both the latter cases one-locus losses are exceptional. It therefore seems premature as yet to draw any conclusions, from this evidence, regarding the frequency with which single loci are necessary to the life of cells. In this connection it may be remarked that Gershenson and Nuzhdin, in collaboration with the present writer and quite independently of the work of Demerec and Stern, have been undertaking some investigations of a very similar nature. The results of these will be presented elsewhere.

The present communication has to report the case of a proved deficiency which is probably far smaller than any previously proved deficiency, and this deficiency is found to be viable. The deficiency in question probably involves the loss of two and only two genes, being the first case in which the actual number of genes concerned in a deficiency, or, for that matter, in any given section of chromatin, has been determined. It proves to be viable not only in single cells surrounded and administered to by normal tissue, or in groups of such cells, but even in the zygote as a whole. And the phaenotypic effects produced by it are of interest from the standpoint of the modern theory of mutation.

The Yellow-Achaete Deficiency Produced by Recombination of Inverted Chromosomes

The deficiency in question was artificially produced by making up an individual in which the homologous *X* chromosomes, by reason of previous rearrangement, contained their genes in a slightly different order from one another, not different enough to prevent single crossing over between the chromosomes, and so allowing the production of complementary types of crossover chromosomes one of which had an excess and the other a deficiency of the non-matching regions (see discussion[14] [pp. 311-313] of the formation of such new combinations by the author). The starting point for the production of the particular deficiency here studied had been given by Serebrovsky's well

*Work of Mackensen, of Demerec himself, and of Sakharoff, using the method of Painter, and published or orally announced since the above was written, have shown the above conjecture to be correct. (Note added July 13, 1935.)

known finding[22] that the chromosome containing the mutation scute-8 contains an inversion in which the left break lies between achaete and scute and the right break to the right of bobbed. Serebrovsky also had obtained deficient and excessive chromosomes as a result of crossing over between this scute 8 chromosome and others (scute 4 and yellow 4) having somewhat different inversions; in fact, it was by the study of the phaenotypes of individuals resulting from just such crossing over that he was led to his interpretation of the structure of the scute 8 chromosome. His accompanying conclusion regarding the separability of achaete and scute has been confirmed by us by means of different methods. But in Serebrovsky's cases the other rearranged chromosomes used were such as to produce, by recombination with the scute 8 chromosome, deficiencies of the active region that were always lethal. In our own work a search was made for chromosomes which might be more favorable for an attack upon the question at issue. It was found that the chromosome containing the mutation yellow 3P provided the necessary material.

This yellow mutation, which has dark bristles and dark abdominal bands like the previously known yellow 3, was found by Patterson and determined by him to contain some kind of inversion. We find that when it is crossed to scute 8 both possible types of single crossovers are obtained in the second generation, not only in the heterozygous females but also in the males. When appropriate markers are present in the heterozygous F_1 individual, as for instance when the genes Bar and apricot are present in the scute 8 chromosome and their normal allelomorphs in the yellow 3P chromosome, as shown in the diagram, both expected crossover types (Bar not-apricot, and not-Bar apricot) appear. The flies of the former class, which contain the left end of the original scute 8 chromosome and the right end of the yellow 3P chromosome, show a normal body color, and show no reduction of bristles. Evidently then the left end of the scute 8 chromosome must contain the normal allelomorph of yellow, and the right end of the yellow 3P chromosome must contain the normal allelomorph of scute (for the scute 8 allelomorph shows some reduction in bristle number, especially on the scutellum). The other crossover class, having the left end of the yellow 3P chromosome and the right end from scute 8, has a clear-cut yellow coloration like that in the ordinary mutation yellow, not like that in yellow 3P, which is darker, and it is at the same time extremely achaete in type (lacking the dorsocentral bristles and neighboring microchaetes and sometimes even the supra-alars and inner verticals); in addition it shows that moderate reduction of scutellar and some other bristles which is characteristic of scute 8 itself. Obviously then neither the left end of the yellow 3P chromosome nor the right end of the scute 8 chromosome contain the loci of yellow or of achaete, but the locus of scute 8 itself is in the right end of the scute 8 chromosome.

In the yellow 3P inversion, then, the left break must have been to the left of yellow and achaete so that the latter loci became carried around to the vicinity of the right end, together with the locus of scute as well, while in the scute 8 chromosome the loci of yellow and achaete (containing their normal allelomorphs) remained at the left end, the break occurring between them and scute, which was carried over to the right end and acquired the properties giving rise to the scute 8 bristle reductions. The second class of crossovers is accordingly deficient for the loci of yellow and achaete but not of scute, since the latter has a similar position in both original chromosomes. The right break of both inversions proves to be in the inert region, to the right of bobbed. It was already known to be in this position in the scute 8 chromosome (see work of Serebrovsky and of Gershenson), and the fact that both crossover classes were proved by testing to contain bobbed showed that in the yellow 3P chromosome bobbed must lie in the same position as in the scute 8 chromosome.

The Same Deficiency Otherwise Produced

We have recently obtained individuals with exactly the same loci deficient, by the use of a rather different method. This involved breaking off the entire left end of the scute 8 chromosome by means of x-rays, either by means of an apparently simple break, as was done in some cases, or by means of a mutual translocation with the fourth chromosome whereby the two fragments of the *X* chromosome were made independent of one another, as was done in another case. The resulting right-hand piece, lacking only the loci to the left of bobbed (see diagram) was then crossed to an individual containing the scute 19 deficiency, in the case of which previous analysis[16] had shown the loci from yellow to some point a little beyond scute to be absent. In the resulting heterozygous female the only loci whose absence was common to both *X* chromosomes were those of yellow and achaete, and here again we find that the individuals were viable and that they exhibited the characteristics yellow and achaete, just like the crossover individuals previously discussed. The achaete character was somewhat more extreme here, however, as might be expected from the fact that the female must carry one more dose of the dosage compensators for this character than does the male.

A yellow-achaete "mutation" found by Koerner in an irradiated scute 8 chromosome while assisting the author in Berlin in 1933 provides a very probable case of still another deficiency of the same region. In the scute 8 chromosome, the location of a part of the inert region, just to the right of the loci of yellow and achaete, provides a favorable opportunity for the occurrence of a deletion having one of its points of breakage just to the left of yellow and achaete and the other point of breakage in the inert region itself, inasmuch as this region is especially subject to breakage. Hence there is much more chance in the scute 8 stock than in normal stocks for a deletion which removes just these two loci of the active region to occur. The "mutation" in question is non-lethal and is sensibly identical, phaenotypically, with the previously described individuals deficient for yellow and achaete, produced by crossing over between the scute 8 and the yellow 3P chromosomes.

Reality and Extent of the Deficiency

The only escape from the conclusion that the loci of yellow and achaete are really absent in the above cases would lie in the supposition that the scute 8 chromosome has these loci duplicated, one set of them lying at the left end of the chromosome, to the left of the left break, and the other set lying at the right end, in the inverted section (a possibility pointed out by the author to other workers on scute, in 1930). But this would require the further peculiar supposition that both these genes at the right end had simultaneously undergone just such extreme hypomorphic mutations that they could no longer manifest themselves through any visible phaenotypic effect of a perceptible kind, *although* still somehow saving the life of the individuals with the apparent deficiencies. Not only would various very special assumptions be required to account for such a condition of affairs, but an intensive study of numerous cases of inversion and translocation has so far failed to reveal one giving any evidence of such a duplication of loci. Many breaks have been studied which occurred in the general region in question, and if breaks had occurred that involved the duplication of any of the visible genes in the region without at the same time totally removing the visible phaenotypic effects of one of these genes, this fact should have been determined by the methods used. Instead of that, the pieces on the right and left sides of each break were always found to be complementary in their effects. It is not denied that duplications may and do occasionally arise by any one of a number of dif-

ferent methods, but it can be seen on the basis of the above considerations that duplications of the type necessary to explain away the present deficiencies, are no more than a very remote academic possibility that we practically need not take into account here.

In regard to the extent of the deficiency, it should be pointed out that we do not positively know that the genes, yellow and achaete, are really separate genes, since neither a crossover nor a break occurring between them has yet come to light. One cannot pass with absolute assurance from the fact that the phaenotypic effects in question are very different and have arisen by independent mutations, to the conclusion that the loci concerned must be separate. For the case of the truncate series of allelomorphs, for instance, long ago showed such effects to be produceable at one and the same locus. However such cases are obviously much rarer than cases of the familiar type; and even in the truncate case many if not most of the mutations did involve simultaneously both of the two different visible characters concerned. All in all, then, it remains extremely likely that two different loci, yellow and achaete, are included in the present deficiency. If so, later work will undoubtedly settle the question by finding separations between them.

Phaenogenetic Considerations

One point of interest from a phaenogenetic standpoint brought out by examination of the deficient individuals is that they do not show a constant absence of all bristles connected with the usual achaete pattern. They give an impression as though the epidermal superstructures had been wiped off over a somewhat limited area; this area is somewhat variable in its size and position, so that on one occasion or another nearly every bristle can appear, and when it does it has a not very atypical position. This shows that the fundamental bristle pattern is determined by other genes than achaete, even though the achaete locus plays a rôle in assisting the production of bristles over a given portion of that pattern, and in fact over a more or less localized portion. In view of this, it seems rather strange and unnecessary that different allelomorphs of achaete should seem to involve somewhat different pattern-effects themselves; they have not, however, as yet shown nearly as much specificity in this respect as the different allelomorphs of scute, and the conclusions from the work on the latter locus may not yet be applied to them.

A second fact of phaenogenetic interest comes out on comparison of the effects of the deficiency with those of mutations of the same loci. It is evident that, phaenotypically considered, the deficiencies of yellow and of achaete belong in the same series with the mutations of these loci, and constitute extreme representatives of their respective series, apparently not more extreme however, at least in the case of yellow, than some of the mutations themselves. This finding illustrates the correctness of the designation "hypomorphs" which the author had attached to recessive mutations of both these loci, and also the correctness of the criterion whereby such "hypomorphism" was ascertained.

By hypomorphism (see papers of Muller, League and Offermann,[17] and Muller,[15]) is meant that characteristic whereby a mutant gene produces an effect similar to although not so extreme as that of a loss of the normal allelomorph. The criterion of such a condition lies in the finding that a reduction in the dosage of the normal allelomorph produces a phaenotypic effect more nearly resembling that of the mutant gene itself, or, *vice versa*, that an extra dose of the normal allelomorph produces an opposite effect from that of the mutant. Alternatively, the conclusion may be based upon studies of the effects of changes in the dosage of the mutant allelomorph, in which case extra doses should give

rise to phaenotypes more nearly approaching, or even transgressing, the normal, while reduced doses give still more extreme deviations in the same direction as already shown by the mutant gene when present in normal dosage. These methods, applied to the cases of yellow and of achaete, lead to the conclusion that the mutations so designated are hypomorphic, i. e., have an effect similar to though not necessarily as extreme as that produced by gene loss. (It is of course not implied here that they actually do involve any loss of material by the genes.)

In the case of yellow, the evidence lay in the finding that one dose of the normal allelomorph in the triploid (even in that containing one deficiency of the locus) failed to produce the full normal "gray" coloration, there being a slight but distinct approach to the coloration seen in yellow flies. In the case of achaete, the evidence rested on the fact that extra doses of an achaete locus containing a mutant achaete gene gave an effect more nearly like the normal than did the normal dosage. The checking up of these conclusions by the present finding that the actual absence of the locus of yellow does give rise to a really yellow color and absence of the locus of achaete to the extreme achaete character, has now provided us with final and direct proof of the similarity between the effects of these "hypomorphic" mutations and those of real losses.

It may be noted that, according to the same terminology, the most extreme mutations of yellow known may be classed as "amorphs" (or even perhaps as "antimorphs" in some cases), rather than as hypomorphs, so far as their phaenotypic effect is concerned. Nevertheless, as is well known, they as well as the hypomorphs may by reverse mutation give rise to the normal gene again, an event which is of course inconceivable in the case of a deficiency having a similar phaenotypic effect. The gene change involved in the hypomorphic mutation is therefore probably in itself qualitative, even though the effect may be described quantitatively.

The question must finally be considered as to why individuals deficient for two loci should be able to live at all. An alternative here would be to admit the sub-gene hypothesis, and to suppose that only a part of each locus had become lost, by reason of the genes in question having both originally been divided internally by the chromosome breaks. We may for the time being, however, lay this hypothesis to one side, firstly, on account of the special assumptions here necessitated by it in order to explain why the whole of the apparent phaenotypic effect of both of these genes becomes lost when this deficiency occurs, and secondly, because of the evidence against the hypothesis provided by the apparently complete identity of positions of the left-hand breaks in the case of scute 19 and yellow 3P, respectively. In our further work on breakages, the proposed possibility must nevertheless be borne in mind, as more evidence as to its truth or falsity should shortly accrue from that work.

Supposing now that the whole of both loci have been lost, we may ask what is the expectation that such a loss should be lethal? Evidence obtained in our recent work, being published elsewhere, indicates the approximate correctness of previous estimates of the total number of genes as lying in the few thousands. This, after all, is not a number of so high an order of magnitude, considering the complexity of the organism, and an individual gene should therefore in most cases have a rather compound as well as a complex rôle to play. Thus, it might seem rather strange that *two* genes which, so far as the purposes of the present problem are concerned, might almost be considered to have been chosen at random, should both, and in fact both together, be so dispensable.

Several explanations are possible, short of radical changes in our conceptions of the rôle of the chromosomes, the number of genes, or the

complexity of the organism. One is the principle previously touched upon, regarding the prevalence of compensatory systems and the overlapping of functions in general. Another is the supposition that the particular genes in question are less basic and perhaps simpler in function than most genes—particularly could this be true in the case of a gene having to do with pigment production in an artificially protected organism. A third is the possibility that in the course of past evolution there may have been some duplication of loci, such as might occur for instance, by unequal crossing over or by means of minute insertions (see parallel paper on scute 19*) (in animals, be it noted, polyploidy as a means of duplication of loci is ordinarily excluded[13]). Any duplication would, of course, eventually be followed by a mutational differentiation of the duplicated loci as pointed out by the author[12] in 1918 (in fact it may with reason be mentioned that *all* present-day loci, no matter how non-homologous now, were ultimately derived by some sort of duplication and mutation from one original gene), but for a very considerable time the duplicated loci should retain partially overlapping functions and meanwhile the loss of one of them would not be nearly so detrimental to the organism, other things being equal, as would the loss of other genes (most of which would have been far more remotely derived from one another). The apparent similarity in the functions of the loci of achaete and scute make the supposition more plausible that these may in the past evolution of Drosophila have been derived by some such duplication from one original progenitor gene. But it must be remembered that the latter idea is still no more than a possibility.†

Addendum

Since all the above was written, a paper by Ephrussi has come to hand, in which the latter brings forward evidence of the viability of small somatic areas presumably deficient for yellow and achaete or yellow, achaete and scute. In one case a scute 8 chromosome with a yellow-achaete deficiency was used, in the other case L. V. Morgan's yellow-scute deficiency; these were "covered" by a deleted *X* chromosome which had a tendency to apparent somatic elimination, and when the presumable elimination occurred, yellow patches having the deficiency were visible on the abdomen. These patches were apparently too small to allow the autonomous nondevelopment of hairs and bristles that ordinarily is associated with the achaete and scute mutations. If the elimination hypothesis is right, then, specific gene-products from normal cells were penetrating, and perhaps also helping to keep the deficient cells alive. Detailed studies have also been made by Gershenson (as yet unpublished), showing the viability even of fairly large thoracic areas presumably lacking the entire left end of the scute 8 chromosome; these occur frequently in ordinary scute 8 material, as had first been noted by Levit in the Texas laboratory, and they show both the yellow character and the absence of hairs and bristles. It is obvious that if the whole individual is viable when deficient for yellow and achaete, patches of this constitution, sur-

*In some conversations which the author had with Dr. E. G. Anderson, many years ago (ca. 1918), in which the former insisted upon the inviability of individuals deficient for then appreciable sections of chromatin, the latter pointed out that duplications of chromatin might have occurred in the past evolution, and that these would tend to permit some deficient individuals to be viable.

†Since the above was written, the salivary gland work of Bridges (1935) and of Offerman (in press) have demonstrated the existence of duplications in the normal Drosophila chromosomes; in connection with these, these authors make speculations similar to our own. (Note added July 13, 1935.)

rounded by normal tissue, should certainly be viable. It is not yet quite certain, however, that in any of these cases of mosaics the chromosome region in question is really absent, or more or less inactivated through some "position effect" that might not extend as far as to the free end of the chromosome.

At present it is of greater interest for us to know how many genes such a large patch may be deficient for. Taking together the purely genetic evidence from our own and previous experiments, we must conclude that the region to the left of scute, *i. e.*, that missing in our own scute 8 deficiencies, includes at least 4 genes: lethal *J1*, chlorotic, yellow and achaete. Judging by its cytological size in the salivary gland, taken in connection with the work of Muller and Prokofyeva[18] on the size of the structure representing an individual gene in the salivary gland, this region probably contains about eight genes in all. Of the four genes specified above, even the most extreme known mutations in two of the loci—yellow and achaete — are not lethal; those in chlorotic are semilethal, and that in *lJ1* is almost completely lethal, only one viable fly having been observed where many thousands would have been expected if the viability of *lJ1* had been normal. This viable lethal *J1* individual had rough eyes and was completely sterile, but was active and long-lived, and except for the associated scute *J1* character, it was otherwise normal in appearance; this lethal effect then is obviously confined to the egg or larval stages. Judging by the *a priori* knowledge that there are at least five to ten times as many lethal as visible mutations, it is highly probable that among the other (unknown) loci in this small region there are several whose mutations, and therefore (since most mutations are hypomorphic) whose losses, would be lethal to the whole individual. It is therefore of especial interest to find some evidence for the conclusion that even the loss of all these loci together is not lethal to individual cells, or even to considerable groups of cells, nourished in an otherwise normal soma. This evidence, taken together with the fact of the viability of the whole individual lacking *both* yellow and achaete, would seem to make a reinterpretation of the findings of Demerec desirable, or at least a further comparative study of deficiencies in which the number of genes involved is approximately known.

Summary

1. A deficiency is described, produced by crossing over between two inverted chromosomes—scute 8 and yellow 3P — in which the resulting chromosome lacks the loci of probably two and only two genes, namely those of yellow and achaete.

2. Individuals having the above deficient chromosome, and having no other chromosome containing these loci, are viable.

3. Such individuals show the phaenotypic abnormalities — extreme yellow and achaete—shown by the most extreme members of the series of mutant allelomorphs already known at the loci in question. The correctness of the previous phaenotypic classification of the mutations of these series as hypomorphic, ranging to (or beyond) amorphic, is thus demonstrated. It is also noteworthy that no other phaenotypic abnormalities were to be observed as a result of the total loss of these loci than had already been observed as a result of their known mutations.

4. A deficiency involving the absence of the same genes was also produced in a different way: namely, by making up females containing one chromosome having the scute 19 deficiency and another X chromosome derived from the scute 8 inverted X chromosome but having the left end amputated by x-rays. Flies with this deficiency so produced were phaenotypically similar to those having the

same deficiency produced by the other method. A yellow-achaete "mutation" in a scute 8 chromosome, probably involving a deletion of these loci, was likewise phaenotypically like the above deficiencies.

5. It is found that the locus of achaete does not govern the laying down of the fundamental bristle pattern characteristic of the region which it affects.

6. Theoretical considerations are discussed, which are raised by the finding of the viability, not merely of cells but of whole organisms, containing deficiencies of genes.

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